Introducing the CSS President-Elect

CSM: Welcome, Professor Antsaklis. As you look forward to being President of CSS in 1997, please describe for us your views on the current state of affairs in the Society.

Antsaklis: Thank you for the opportunity to present my views from the pages of the *Magazine*. First, I would like to say what a great honor it is to serve as President of the Society, which is nationally and internationally recognized as the premier scientific and engineering organization dedicated to the advancement of the theory and practice of systems and control. Thanks to the work of all the CSS volunteers and my predecessors, I am fortunate enough to lead a society that is in very good shape in all aspects. Technically we are at the top of our field. Our publications are well run and enjoy a fine reputation. Our conferences are thriving. Financially we are in excellent shape. I was recently at an IEEE TAB (Technical Activities Board) meeting where all the IEEE societies were represented, and I must tell you that the CSS is one of the best run, and technically one of the most respected, societies. The CSS is growing; it is active and very vibrant indeed. So I am fortunate not to have to spend all my energies in major reorganizations and restructuring of the Society or putting out forest fires, but instead I need to do only fine-tuning at this time. And so I can devote my energies to looking primarily at the future, at certain longer range issues of greater interest and importance to our membership.

CSM: Tell us first about your involvement with the CSS.

Antsaklis: My involvement with the CSS started when I was a graduate student, when I was asked by my advisor to review papers for the *Transactions*. Since then I have served in many capacities. Early on I was involved with the membership development committee, and I also was an Associate Editor for the *Transactions on Automatic Control*. More recently I was an Associate Editor for the *Transactions on Neural Networks*, an Editor for the IEE Control Book Series, and have also been involved with conferences. I was the Program Chair of the 1991 CDC in Brighton, England, General Chair of the 1993 IEEE International Symposium on Intelligent Control (ISIC) in Chicago, and General Chair of the 1995 CDC in New Orleans last December. Just before I was elected President-Elect, I served as CSS Vice President for Conference Activities for two years in 1994-95, and as a member of the Executive Committee. I have also served as an elected member of the Board of Governors for two terms, and I was the chair of the committee that produced our CSS brochure a couple of years ago.

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CSM: Is it necessary to serve in so many ways before serving as President of CSS?

Antsaklis: I think yes, if the President wants to make a difference. A person needs to understand how the society works in order to introduce and implement important changes that will make a difference for the better. Being President is of course prestigious, but if the only reason for having the position were the prestige, it would not be worth being President, in my opinion. A person needs the knowledge, the maturity, and the understanding in order to make worthwhile contributions in an organization such as the CSS.

CSM: Tell us about the 1995 CDC.

Antsaklis: It was great! The attendees enjoyed New Orleans, liked the hotel, appreciated the food, and thought that it was a very technically successful conference. One of the innovations was offering the Proceedings on CD-ROM, introduced for the first time; they were given at no additional cost to all attendees, and were very well received.

CSM: Tell us about your interest in control.

Antsaklis: I studied control systems at Brown University, where I was awarded my MS and Ph.D. degrees under the supervision of Bill Wolovich. I specialized in linear control systems described by polynomial matrix and fractional descriptions. In those days, I remember, we had to describe what we meant by such polynomial descriptions and justify their use every time we were making a presentation or writing a paper, as the state-space description was the only thing we needed (or so they said!). It was fun, but also frustrating at the same time, to be involved in something so different. It was also very satisfying, especially later on when these descriptions became very

important in characterizing all stabilizing feedback controllers; this was the result which opened the door to new approaches to optimal control which were not based on state-variable descriptions. In fact, the IEEE Fellow recognition I received recognizes my contributions in the feedback stabilization area using primarily polynomial matrix descriptions.

CSM: What about your previous background?

Antsaklis: To start a bit earlier, I was born in Greece and I attended the National Technical University of Athens, where I got my Diploma in Electrical and Mechanical Engineering. It was exciting to teach for a semester at my old school as a Visiting Professor during my sabbatical leave in 1992. Just before going to Greece in 1992, I also spent some time lecturing at Imperial College in London, where I had my first tenure-track job as a Lecturer. After I graduated from Brown, I spent one year at Rice University as visiting faculty, working with Boyd Pearson, and then I moved to England. I have been at the University of Notre Dame since the time I left Imperial to return to the U.S. I spent my first sabbatical in 1987 at MIT, and my 1992 one in Europe.

CSM: Tell us about your life at Notre Dame.

Antsaklis: I am married and my wife, also a Brown Ph.D., teaches Russian literature at the University of Notre Dame. Our daughter, Lily, is seven years old and she keeps us very busy, as any parent of a small child can tell you. At Notre Dame, in the Electrical Engineering Department, I am teaching both undergraduate and graduate students, and this is something I enjoy very much; the undergraduates must enjoy it, too, since I have been awarded an undergraduate teaching award. I am rather heavily involved in research, and I think controls is a wonderful area that has both interesting and challenging mathematics, as well as exciting applications. I am also serving in several department and university committees, and I am the department's Director of Graduate Studies. I am the director and one of the teachers of the Greek school in our area; in fact I started it about four years ago. And of course I serve in the CSS. Ah yes, I also serve as a Director in AACC, the organization that runs the ACC.

CSM: How do you balance teaching and research?

Antsaklis: In a school that values personalized education, it is difficult sometimes to balance a very active research program with graduate students and postdocs and proposal writing, with committee work at the departmental, college, and university levels, and with professional activities at the national and international levels. Sometimes it gets to be a bit much, but it is exciting and I think it provides the right perspective, a strong sense of the difficulties in achieving the balance we all strive to achieve between our career, professional activities, and family life. I can tell you that the whole thing pays off if you feel that you made a difference. Throughout my career I have tried very hard to do exactly that: make a difference.

> **"We need to enhance and improve the way we have been teaching control systems."**

CSM: Describe for us some of your recent technical activities.

Antsaklis: As you know, my research in recent years has been in the area of intelligent control, that all-encompassing area that tends to include everything that it is not characterized as conventional control. The area has, of course, a shifting boundary, and what is called "intelligent control" today will probably just be called "control" tomorrow. This message was conveyed in the report by the CSS Task Force I chaired on "Defining Intelligent Control," published in the *Magazine* in the June 1994 issue. I have been interested in neural networks and in learning, and I was the guest editor in a number of special issues in the *Magazine* on these topics.

CSM: What are your specific research interests?

Antsaklis: My current research interests are in hybrid systems which appear in applications whenever, for example, a continuous system is controlled by a digital computer; such systems are very important in intelligent control. Hybrid systems consist of interacting time-driven subsystems, described by differential or difference equations, and event-driven discrete event systems subsystems, described for example by automata or Petri nets. I have been interested in the modeling, analysis, and supervisor synthesis of such systems. As a matter of fact, Anil Nerode of Cornell and I are putting together a special issue on hybrid control systems for the *Transactions on Automatic Control*; keep an eye out for it, it will be an exciting issue.

CSM: Let's return now to CSS issues. Describe first, if you will, how you see your role as President-Elect of the Society.

Antsaklis: My role as President-Elect is to head a long range planning committee and generate some vision for the Society and membership. I have decided that instead of concentrating on improving procedures or developing methods to increase the membership, to concentrate instead on the bigger issues: for example, where we are as a group and where perhaps we should be moving so as to be able to design the control and decision-making mechanisms of the 21st century. From many discussions I had over the years with members from around the world, I know that these issues concern many of your readers.

CSM: What, then, are important issues the Society and its members will be facing in the future?

Antsaklis: What makes control different today from the way it was, say, 20 or 30 years ago, is technology. Sensors, actuators, and digital computers are all better, faster, and cheaper while providing many more capabilities than we ever dreamed of or asked for. Communication technology has also opened the channels, so to speak, to fast, reliable data communication among distributed controllers, making it easier than ever to implement large numbers of such controllers. All indications are that this trend will continue and the technology will keep improving along these and other fronts, opening new exciting horizons for control. New technologies offer tremendous opportunities for design and implementation of new-generation control systems, systems we have not seen or did not think would be possible to implement before. How can we take advantage of these exciting and unique opportunities? This is, I think, the main issue that needs to be addressed by the members and the Society as a whole.

CSM: How should we respond to new technology?

Antsaklis: There are several things that can be done; I can try to highlight the issues, but cannot offer complete solutions. I expect that complete plans for action will only emerge after significant open discussion of the issues, a lot of debate, and perhaps arguments. So the question is, what can we do today to take advantage of existing and future technologies that are and will be used to implement advanced control systems? Our research, or at least part of it, should be influenced by technological advances. When we design controllers, the (digital) implementation issue should be an integral part of the design; here I am perhaps influenced by my personal research interests in hybrid systems. It seems that many of our control methodologies have their origins and are influenced by basic building blocks of control mechanisms that are closer to RLC circuits than the sophisticated CPUs of today. I do not have the magic answer here. But I feel that if we pay closer attention to the control implementation issue, answers or partial answers are bound to emerge. I firmly believe also that such an approach will lead to fundamental and challenging theoretical questions which will require solutions. To learn about these wonderful advances in control technology, we have to learn first about the new challenging applications of control. Such knowledge can only come with the help of control engineers who work with such applications.

CSM: What is the role of industry along these lines?

Antsaklis: There is a great role industry can play here, which can take many forms. Models and problem descriptions may be provided, along with descriptions of available or desirable sensors and actuators. Workshops on particular classes of control problems can be organized with the help of industry to bring together interested practitioners and researchers. Research money could be provided to support specific projects, and exchanges and partnerships between industries and universities could be encouraged. I think that industry should be and will be playing a new expanded role in the future in view of the industrial control challenges and the federal funding realities. I think such partnerships between industry and universities are better developed in other countries than in the U.S., particularly in Europe and Japan, and so models to develop such partnerships do already exist.

Closer relations between industry and universities will also make it easier for the research to be applications-driven. This is, I think, very desirable as it will not only help solve important problems, but it will also help identify significant new directions in control theory and create new control subdisciplines. Recall that the greatest mathematicians over the centuries were quite familiar with the important practical problems of their day.

CSM: So, mathematics will still play a vital role?

Antsaklis: In our pursuit of excellence we should concentrate on fundamental discoveries. But let's not immediately equate fundamental results with mathematical results. There is a strong overlap, of course, but the overlap is by no means complete. For ideas, let's look at the fields of computers and of communications, for example, and their success in the last 30 years. These areas, although they can and do have a very strong mathematical research component, also welcome and nurture contributions along other fronts as well. I am afraid we have not been as welcoming in the control systems area, and I think if we are to change, now is the time to change and be more open-minded. Certainly I am not advocating relaxing the rigor and the high standards in our research contributions. Believe me, however, there is plenty of room and need for all kinds of discoveries, if we are to meet the control needs of the 21st century.

> "What makes control different today ... is technology."

CSM: Where does the university fit into this picture?

Antsaklis: To make all this possible, we will need to implement innovations in the university curriculum. If we are to build the control systems of tomorrow, we need to enhance and improve the way we have been teaching control systems. We will need to also talk about the technology that exists and to introduce material that makes it possible to use that technology in an integrated way. Our students are typically able to handle continuous-time systems and discrete-time systems in the time and transform domains. They will also need to learn some logic, automata theory, Petri nets, etc., so they may be able to handle event-driven systems as well; computer engineering courses on discrete mathematics may be appropriate. Other material may, of course, be incorporated; for example, biological systems may suggest architectures for novel control and decision-making approaches.

We should also be taking advantage of available information technologies for the dissemination of information. Courses and experiments on the Web have already started, and I expect many more innovative uses to emerge in the near future. Exchange of information via the Internet is a very rapidly evolving area, and we certainly should keep a close watch on the developments there.

CSM: It appears that control engineers, whether from university or industry, all have a stake in this.

Antsaklis: Yes, and there is another issue here which is perhaps related. We are not visible enough as a group, even among fellow engineers. This is important, as many decisions which affect our members, such as federal funding, are made based on the perception of the importance of what we contribute to society. It is therefore important to ask ourselves about the impact we have in science and technology. It is certainly true that our methodologies have been used in thousands of applications to improve their operation, and it is also true that only with the help of our methodologies certain applications were made possible. But it is a fact that we cannot say today that we are recognized for our contributions as much as we should be. There are many reasons for this, I believe, such as the fact that we tend not to follow through with our designs, and so we keep some distance from applications. There are other reasons as well, of course, that perhaps we tend not to advertise and explain well enough. Shifting our research a bit more to applications-driven research can only help us along this front; one could look at improving visibility as a side benefit in this case, although I think this issue demands much more attention, and should be addressed on its own.

CSM: How can the Society and its members respond to these challenges?

Antsaklis: Each of us, each member, will have to decide on her or his own what part, if any, to play in these initiatives. As

a Society we can only facilitate and encourage. Here are some ideas that could be pursued; they are mentioned in no particular order. We could organize workshops to map new research directions, together, for example, with NSF. Here the Society can take the initiative via its technical committees. I think the Society can play a significant role, for instance, in education through model courses, short courses, and extension courses; in control research directions, through workshops in robotics, in communications, and in biology, for example; and in dissemination of information and electronic publishing. We could also establish a task force on control education to identify the new tools and ideas and suggest ways to implement them. We could, for example, start by recommending initially a Master's control program that incorporates the elements we discussed; maybe some universities have such program already in place.

I would like to hear from the readers, preferably via email. Let me know your ideas. We have to think about the future of control, about how to meet the ever-increasing control and decision-making demands our technological society imposes. We need to decide in a proactive and systematic manner what is the best way to meet the control needs of the 21st century. We may decide, against all reason in my opinion, to do nothing; but if this is the case let it be a conscious decision and not the result of lack of action on our part.

CSM: Any closing thoughts?

Antsaklis: Only to say again what a great honor it is for me to serve as President of such prestigious and vibrant group. We are at a turning point in control reminiscent of the 1960s, but more exciting in my opinion. We are ready, I think, to spread our wings, to incorporate the new technologies and build even more successful control systems than the ones we have built in the past. Let's introduce new ideas, new concepts, and new mathematics to meet the new challenges, while we continue excelling in the rigorous, high-quality research we are famous for. We are in control, and together we will meet the challenge.

CSM: Thank you, Dr. Antsaklis, for an exciting and informative interview. You have certainly presented some challenging problems and given us food for thought. Best wishes for a successful term as President of the CSS in 1997.