

Profile of Mustafa Khammash

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- *Notable awards:* IEEE Fellow; Fellow, International Federation of Automatic Control.

Basel, the center of life sciences in Switzerland.

Q. What courses do you teach? Has your teaching changed since your move?

Mustafa: While at UCSB I taught several classes in control. I particularly enjoyed teaching the graduate class on robust control and the undergraduate introductory class on control systems. Here at ETH, I am not teaching any classes that are dedicated to control. Instead, I am incorporating control concepts in classes on systems biology.

Q. What are some of the most promising opportunities you see in the control field?



Mustafa Khammash, professor of control theory and systems biology at the Swiss Federal Institute of Technology (ETH Zürich) exploring his new surroundings in Switzerland.

Mustafa: There are many promising opportunities in the control field. Specific areas include energy systems, micro/nanoscale systems, economics, and systems and synthetic biology. The latter is my current area of research. Here, I would like to mention an emerging area that I call *cybergenetics*, a 21st century version of Wiener's cybernetics. I am referring to the use of modern genetic techniques to achieve real-time feedback regulation of living cells. The confluence of genetic manipulation methods, powerful experimental measurement technologies, and advanced analysis and computational methodologies is making the control of living cells feasible. I believe that this holds tremendous opportunities for both research and applications.

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

Mustafa: I enjoy reading, hiking, and photography. After moving to Switzerland, I am taking up a new interest—skiing.

Q. Thank you for your comments.

Mustafa: Thank you for the interview. It has been a pleasure to share my thoughts with *IEEE Control Systems Magazine* readers.

BOZENNA PASIK-DUNCAN

Q. How did your education and early career lead to your initial and continuing interest in the control field? What are some of your research interests?

Bozenna: I have always been fascinated by stochastic modeling and making connections with it. While studying and working on my scientific degrees, from a master's degree

and Ph.D. to a habilitation doctorate degree, I had naturally expanded my research areas from numerical and computational methods that could be applied to stochastic processes and stochastic differential equations, and their uses in stochastic modeling and adaptive control, which is the area of research that led me to the habilitation doctorate. I had found that stochastic systems and adaptive control bring together all of those areas of mathematics that I had studied and opened a new door for stochastic

modeling and provided new opportunities for making connections with it.

I had remarkable math and science teachers throughout my K-12 education and later on at Warsaw University in Poland. I studied mathematics, and I was always interested in applications of mathematics. It was natural for me to choose the Warsaw School of Economics to collaborate with economists and to teach and prepare future economists for opportunities and challenges of that time. Working on problems and projects in economics made

me aware that there was a need for adding control in stochastic modeling.

In 1978, I joined the control research group at the Institute of Mathematics of the Polish Academy of Science, where I became fascinated by stochastic adaptive control theory, in particular, adaptive control of Markov chains. I had found that stochastic adaptive control brought together all those areas of mathematics in which I was interested at that time:

stochastic analysis, control theory, mathematical statistics, and numerical and computational analysis. Last May, the group reunited in Poland to share its recent contributions to stochastic analysis and control, and I enjoyed giving the talk, "30 Years Later: On Discrete Time Linear Quadratic Control with an Arbitrary Correlated Noise."

In 1980, this same group organized the semester on control where I met many international control scholars, including my husband. I like joking with students that stochastic adaptive control is like a marriage of identification and control. I had worked on identification and estimation, and I needed control, so I married a control person, and together we have solved many open problems, and we continue enjoying our collaboration.

We both believe in a collaborative effort, and we both like being motivated by industrial problems. Practice has recently generated the need for the development of new stochastic analysis methods such as fractional Brownian motion calculus. Our research area expanded naturally by modeling noise in stochastic systems by fractional Brownian motion, which is a nontrivial generalization of Brownian motion. Very recently, we focused our research on stochastic systems with a general class of correlated noises.

I love learning from, and working with, people from different disciplines. I believe that collaboration is a key to

success in solving complex problems of the modern world. I believe in the power and the beauty of systems and controls, a field that spans science, technology, engineering, and mathematics (STEM). Our field is never old. It continuously generates new problems and brings the excitement of new discoveries. It is a fascinating field that attracts other fields. While working in this field, I continue being excited about it, pas-

sionate for learning more, and never stop feeling young.

Q. What courses do you teach relating to control? How would you describe your teaching style?

Bozenna: At my university I developed a stochastic adaptive control course for advanced undergraduates and graduate students from different schools and departments, including the engineering, education, and business schools; the departments of mathematics, physics, biology, chemistry, geology, ecology, and economics; and also for the psychology and data analysis units. The course brings together a very diverse group of students. It has become a popular course with a strong reputation of being, "the best course I have ever taken at KU," according to former University of Kansas students. The course focuses on estimation, identification, filtering, control, and adaptive control of stochastic systems. Students are engaged in making connections between probability, mathematical statistics, stochastic differential equations, stochastic processes, and computational methods.

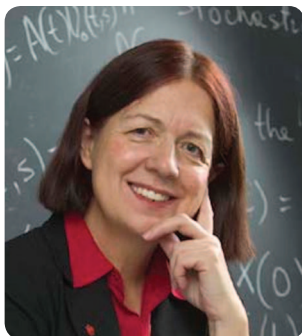
I like interactive teaching and teamwork, and I promote integrating research and teaching in the classroom at all levels. Students in the classes that I teach are engaged in both learning and teaching. They work on projects and problem solving. While

working on problem solving, they discover which areas of mathematics they need to know and what kind of technology tools they need to use for finding solutions. They work in multi-scientific teams. They implement each other's knowledge, just like we do in our collaborative research. I prepare students for this course by teaching them courses in probability, stochastic processes, and mathematical statistics. I am passionate about giving students a good understanding of randomness and uncertainties.

I enjoy teaching everyone probabilistic thinking, and I enjoy applying probability in real-life situations. When going to court to defend myself after getting a speeding ticket and being asked by a judge, "Is it true that you drove 45 mi/h in a 30-mi/h zone?" I respond with: "Your Honor, with probability zero I drove 45 mi/h in the 30-mi/h zone." In this way, I advocate for probability as a discipline that can be useful and helpful, not only in research but in everyday life. I think about controls in the same way.

I believe in bringing guest speakers from industry to the classrooms. Almost all of my former students work in different areas of industry, such as telecommunications, insurance, actuarial, finance, and biomedicine. Bringing them back to the classrooms to share their experiences and discuss the problems they have been working on has been the most inspirational and the most powerful method for motivating students to study stochastic systems and control. These successful former students serve as role models, and it is natural that current students want to follow them, believing that they can become equally successful.

I have been currently working on redesigning Calculus I for engineers, a course for 550 students that I will be teaching this Fall to move from a traditional lecture/labs format to a hybrid course with lecture notes available for students online. This format of course will allow students to be engaged in a more interactive and more effective way of learning and teaching.



Bozenna Pasik-Duncan.

Profile of Bozenna Pasik-Duncan

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- *IEEE Control Systems Society experience highlights:* vice president, Member Activities; member, Board of Governors; founder, Women in Control Group; liaison to the IEEE Women in Engineering Committee; deputy chair, Technical Committee on Control Education; liaison to the IEEE Society on Social Implications of Technology.
- *Notable awards:* IEEE Fellow; Fellow, International Federation of Automatic Control; IEEE Third Millennium Medal; Distinguished Member of the Control Systems Society; University of Kansas Women's Hall of Fame; Polish Ministry of Higher Education and Science Award, 1975; University of Kansas HOPE (Honor to Outstanding Progressive Educator) Award, 2002; Service to Kansas Award, 2011.

Q. What are some of the most promising opportunities in the control field?

Bozenna: As I already mentioned, the control field spans STEM, and as such it has the most promising opportunities for solving the most challenging problems in emerging areas of the modern world that include robotics, bioscience, neuroscience, finance, health care, energy, earthquakes, and tornados, to mention only a few. I live in Kansas, a state that is regularly hit by tornados. I cannot stop thinking about finding better methods of predicting them. My daughter has just graduated in electrical engineering with collaborations in neurology, neuroscience, computer science, and mathematics, and her research focus is on the brain, one of the most complex systems. She has experienced a very high demand for engineering, technology, and mathematics at medical schools. Neurologists already believe in the power and the promise of using systems and control approaches and methods. With open eyes and minds for collaboration with scientists in nontraditional engineering areas of research, the future for the control field and for our students looks bright.

Q. What you can tell us about educational activities in which you have been involved for a long time?

Bozenna: My mother always reminded me about my true passion and love: "Remember, you were born to be a teacher and to help others." As a teenager, I ran a summer school on Sundays for all the K–12 students in the Polish villages where I used to spend my summer family vacations. I taught math, my sister who was a professional singer taught singing, and my mother enjoyed baking cakes and cookies for the many kids. We were sitting on the grass with no blackboard or calculators and enjoyed doing math. That time brings back beautiful memories and provided invaluable experience.

I didn't know the American educational system when I moved to the United States. I was fully educated in Poland. I often say, I left Poland but Poland never left me. I still use Polish books, even those that I wrote for teaching calculus or probability or mathematical statistics, and I have been collaborating intensively with Polish mathematicians. However, I wanted to know the American K–12 system so I started to volunteer to teach probability and algebra when my daughter was a second grader.

By the time she was a fourth grader, I was going to her school four times per week to teach 17 students probability and algebra using American, French, and Polish books, while working full time at the university. I did that for four years. My students won every math competition in problem solving. Not only that, but I learned about the American education system; I made many friends with teachers, students, and parents; and I became excited about helping American students. They made me happy in this country.

I feel strongly about giving back to communities. Twenty years ago, I started the Mathematics Awareness Month educational activities that included the math competition for grades 3–12 and workshops for 5th and 6th graders at my department. Almost all math faculty and students are involved in those annual activities, which are held in April. Each year the mayor of our city and the governor of our state proclaim April as Mathematics Awareness Month in Kansas and "urge all its citizens to join in this observance."

I carried on this successful model, and in 2000, with the encouragement and the help of the Engineering Program of the National Science Foundation and the help of many officers and members from the IEEE Control Systems Society (CSS) and American Automatic Control Council (AACC), I organized the first NSF workshop, Ideas and Technology of Control and Systems, for high school teachers of mathematics and science at the 2000 American Control Conference (ACC) in Chicago and brought 50 invited outstanding teachers from different states. The purpose of the workshop was to increase awareness of the importance of educational activities that demonstrate the power, beauty, and exciting aspects of systems and control technology and its cross-disciplinary nature among high school students and teachers. The success of all STEM fields depends on attracting the most gifted young people to the science and engineering profession. The control community came to

the conclusion that early exposure to middle and high school students and their teachers is a key factor.

This year was the 13th anniversary of these popular and successful workshops, which have been held at almost every ACC and IEEE Conference on Decision and Control (CDC) since 2000. A special session that summarized the educational activities and history of the workshops was held at the 2013 ACC in Washington, D.C. Documentation is on the Web pages for the CSS and AACC Technical Committees on Control Education.

More than 130 presentations were given by more than 70 presenters at the workshops. The presentations were given by control systems researchers and educators from academia and industry at all levels, from graduate students to distinguished scholars. The feedback from students who have attended those workshops has been fantastic. All of them declared to be control engineers, and maybe as the president of AACC commented recently, the recent significant increase in participation at ACC is the result of our educational activities.

Some of the best short Plain Talks are currently available. They are suitable for a wide range of the public and were developed to be educational, inspirational, and entertaining, while showing the exciting character of the STEM fields. The number of control people—in particular, young people—who have been involved in educational activities has been increasing exponentially. Other organizations and communities have followed the model that we developed. The CSS and AACC have recognized the importance of these activities and have been very supportive.

Q. You were the founder of the Women in Control Group and then the first chair of the Standing Committee on Women in Control. What motivated you to start these organizations? Is the number of women in control increasing?



Bozenna Pasik-Duncan (right) with husband Tyrone Duncan and daughter Dominique Duncan at an IEEE Conference on Decision and Control.

Bozenna: I attended an all-girls high school, and as the president of the student body I had a dream to help all of the girls at school to be their best. Together we took the challenge to compete with all-boys high schools, and we won. Since that time, I have become the strongest supporter and advocate for women in the STEM fields.

The program chair of CDC 1987 brought to my attention that there were only two women among its 700 speakers. That surprised me, and I quickly responded to the situation. I started working on bringing visibility to women in control. With the help of other CSS members, and particularly with the help of other women, the Women in Control Group of the CSS was founded, and then the Standing Committee on Women in Control was formally formed and I had the privilege to be its first chair. We celebrated the 25th anniversary of Women in Control at the last ACC in Washington, D.C. I am very proud of the accomplishments and achievements of so many remarkable women in control.

I am grateful and thankful to the CSS and its many members for the support and recognition provided to women. Women in Control has brought important visibility to women, and women in control have achieved a lot (17 IEEE Fellows, two CSS presidents, many ACC general and program chairs, and a current AACC Executive Committee member are women), but there is still a long way to go. The

Society is still less than 6% women. I believe that the successful educational activities and outreach program have a high potential to attract more women to the control field.

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

Bozenna: Music, art, traveling, and balancing among different cultures. The University of Kansas is proud to have the spectacular Lied Center. I served as a member of the Lied Friends Board as the first mathematician elected to the board. Although I do not play any musical instrument and I do not sing, I love to listen to music and singing. As a board member, I had the privilege and honor to meet many distinguished artists and watch many amazing performances. I brought some artists to my math classes and challenged students to find links between music and mathematics. I serve frequently as an outside member at doctoral examinations in the Music Department. Music is always with me.

I never missed a Friday concert at the Warsaw Philharmonic Hall or any important opening of a new art gallery in Warsaw. I brought with me my special collection of Polish art, and I currently serve on the Education Program Board at the Spencer Museum of Art at the University of Kansas. I enjoy finding connections between art and mathematics.

Traveling, with its new discoveries is another passion of mine. And, of course, balancing between American and Polish cultures is my true hobby, whether in teaching, research, or my family life. My daughter grew up in both cultures. Besides balancing between two different cultural lives, the three of us balance overlapping, but different, professional lives: engineering, mathematics, science, and neuroscience. The beauty of different

cultures fascinates the three of us. My daughter currently teaches three math summer courses in Chengdu, China. She loves her new students, and she loves her new discoveries there, and I love going back to Poland and sharing my American discoveries and experiences. The title of my career talk is: "From a Polish Space to the Land of Oz." A Polish space is a topological object, and the land of Oz is Kansas.

Q. Thank you for your comments.

Bozenna: Thank you very much for giving me the opportunity to share some of my passions with the readers of *IEEE Control Systems Magazine*. Let me take the opportunity to thank many of them for their beautiful friendship; for joining me enthusiastically on very many important and challenging tasks, projects, and activities; and for their remarkable contributions to them.

GANG TAO

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

Gang: My undergraduate major was in automatic control. The study of feedback ideas, root locus, and Bode plot techniques led to my initial interest in control theory (drawing those plots by hands gave good insights into the principles). By the time I entered graduate school, I learned linear systems, digital control, and some of the then-modern control theory and techniques. My interest in adaptive control was developed in my Ph.D. study, supervised by Prof. Petros Ioannou, and continued for many years in my research. My interest in solving new problems is still growing.

Q. What are some of your research interests?

Gang: My research is in adaptive control, with particular emphasis on adaptive control of systems with multiple inputs, multiple outputs, and with nonsmooth nonlinearities and in design, stability, and robustness of multivariable adaptive control systems. Recently, I have been working on adaptive control of systems with actuator and sensor failures, structural damage, and uncertainties, with applications to aircraft and spacecraft flight control systems under such adverse conditions.

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Gang Tao at the historic town of Santiago de Queretaro, Mexico (a UNESCO World Heritage Site) (photo courtesy of Yu Tang).

Q. What courses do you teach relating to control? How would you describe your teaching style?

Gang: Over the years, I taught control courses including linear feedback control systems, linear systems theory, optimal control, multivariable control, digital control, nonlinear control, adaptive control, and robotics. When teaching control theory, I remind students to see the physical meaning of a mathematical equation and also to give the mathematical description of a physical concept. I have found this approach makes it easier to learn and to teach as well. Building such connections is an emphasis I put on my teaching,

in addition to clarity and simplicity, which I think are also useful for effective lecturing. Clarification and simplification are often necessary when teaching control theory that may seem complicated to students when they see it at the first time. The use of physical concepts in explaining difficult theorems does a lot to help students understand them, especially those lemmas and theorems in adaptive control and estimation theory.

Q. What are some of the most promising opportunities you see in the control field?

Gang: I think that effective control of systems under abnormal