In this issue of *IEEE Control Systems Magazine* (*CSM*) we speak with Yasamin Mostofi, assistant professor in the Department of Electrical and Computer Engineering at the University of New Mexico. Yasamin has received an NSF career award as well as a Distinguished Research Award at the University of New Mexico. Her research is in the areas of mobile sensor networks, communication-aware motion planning, and distributed sensing.

We also speak with Dale Ulrich, professor of movement science and physical education in the School of Kinesiology at the University of Michigan. Dale received the B.S. and M.Ed. from West Chester University, Pennsylvania, and the Ph.D. from Michigan State University in human performance and special populations. Dale runs Bike Camp, which allows children to learn to ride bikes by taking advantage of technology developed by Richard Klein. Richard's work on bicycles is used extensively in programs operated by Lose the Training Wheels, Inc. The technical background on bicycle dynamics was the subject of the *IEEE Control Systems Magazine* article "Bicycle Dynamics and Control," by K.J. Astrom, R.E. Klein, and A. Lennartsson, which appeared in the August 2005 issue.

YASAMIN MOSTOFI

Q. Why are cooperative sensor networks interesting as a research topic? What are some of the benefits and challenges of this technology?

Yasamin: The unprecedented growth of sensing, communication, and computation in the past few years has the potential for fundamentally changing the way we interact with our environment. The vision of a multi-agent robotic network cooperatively sensing, learning, and adapting in harsh unknown environments to achieve a common goal is closer than ever. A mobile cooperative network, for instance, can help with a search-and-rescue mission, mine exploration, or perimeter defense and can venture to areas dangerous for humans. Small sensors are already being used to study things we cannot directly observe, such as animal habitats or glacier movements. In such static networks, energy efficiency is typically one of the main challenges as there may not be a chance to recharge the nodes.

When it comes to mobile robotic networks, however, there are still several challenges to address before we can realize their full potential. While mobility creates new possibilities for cooperative operation, it also poses new research problems in terms of decentralized control and motion planning. When combined with the real-time nature of some applications, such as search-and-rescue and power/bandwidth constraints, designing a robust cooperative network becomes even more challenging. As a result, the best solutions are not the product of research in any one area since the traditional approaches in control or communication will no longer suffice. We need a multidisciplinary approach in which we develop a foundational understanding of the interplay between sensing, communication, and control.

Yasamin Mostofi, assistant professor at the University of New Mexico.

Q. You use the term "communication-aware control and motion planning" to describe your research. Can you explain what this area is about?

Yasamin: I use the term "communication-aware control and motion planning" to refer to our integrative approach for mobile networks, where we incorporate measures of communication quality in control and decision making. Communication plays a key role in the overall performance of cooperative mobile networks. Communication between mobile agents can be degraded due to factors such as path loss, shadowing, or fading. Therefore, to ensure robust, timely operation, we need to use realistic link models and characterize their impact on control and decision making. Furthermore, both communication and control issues need to be jointly considered in the design of these systems. In the robotics and control community, considerable progress has been made in the area of cooperative multi-agent networks. However, over-simplified link models are typically used and therefore the knowledge available on channel characterization from the communications community has not been exploited.

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My research group is currently working on various aspects of communication-aware control with the support of the Army Research Lab and the National Science Foundation. For example, we use probabilistic models to characterize the underlying dynamics of wireless channels. For mobile networks, the trajectory of a robot affects its link quality. Therefore, measures of channel quality need to be taken into account in motion planning. Along this line, we have developed a probabilistic framework where each node predicts its information gain from both sensing and communication to generate its optimal trajectory. As a result, each node makes smarter motion decisions, which increases the chance of maintaining connectivity and accomplishing the overall task. We are also working to determine the spatial predictability of a wireless channel, as this predictability will impact how well we can learn and incorporate channel knowledge in control and decision making. Since there will always be uncertainty in channel prediction, we then characterize the impact of channel uncertainty on the probability of robust operation.

Q. Describe your educational background. Also, how did you originally become interested in this research?

Yasamin: My interest in engineering goes back to my high school days where I found math and physics classes fascinating. Unfortunately, with few women in engineering fields back then (and even now), I had to fight a good battle with my family to convince them to let me go into engineering as opposed to medicine. Fortunately, I ranked 11th in the national university entrance exam in Iran, which allowed me to enroll in the electrical engineering program at Sharif University of Technology, the best school of engineering in Iran. In my junior year, I became interested in communications and as a result did my B.S. thesis on designing blind feedback-based equalizers that estimate both the communication channel and the transmitted information with no a priori knowledge. I then continued my graduate studies at Stanford University, where I received both my M.S. and Ph.D. At this point, my research was still focused on wireless communications. In particular, I worked on solving the challenges of utilizing orthogonal frequency division multiplexing (OFDM) technology in high-mobility, single-frequency networks as relevant to digital video and audio broadcasting systems.

After completing my Ph.D. in 2004, I was ready to expand my research activities and explore new problems. At that time, there was a growing interest in sensor network applications with new and exciting research challenges. Thus, when I saw an advertisement for a related postdoctoral position in Richard Murray's group at Caltech, I seized the opportunity. Although this meant that I had to switch my field to some extent and venture into a new area, I felt that the broader perspective would better prepare me to work on multidisciplinary sensor network problems.

After two and a half years as a postdoc, I joined the University of New Mexico as an assistant professor in the Department of Electrical and Computer Engineering. Currently, my research is at the intersection of communication and control, with the aim of understanding the theoretical foundations of distributed sensing and decision making in cooperative networks. An important research focus, supported by my NSF career award, is the development of foundations for sensing and navigation in mobile cooperative networks from a compressive sampling perspective. Essentially, we use the recent breakthroughs in compressive sampling theory to understand the fundamentals of cooperative exploration based on minimal sensing. As a whole, our research efforts seek to characterize the minimum sensing and communication needed for the robust operation of cooperative mobile networks.

Q. How do you find the American educational system compared to the education in Iran?

Yasamin: For most parts, the two systems are quite similar. However, in Iran there is more emphasis on theory than practice. For instance, a typical high school education in Iran involves taking several advanced subjects in mathematics. We had separate classes for algebra, geometry, trigonometry, and logic almost every year in high school, which I definitely enjoyed. However, my high school did not offer a single lab class. On the other hand, American education fosters creativity and leadership through hands-on projects and group activities. At the undergraduate level though, the two systems become more similar.

Another difference is in the admission process to the universities. In Iran, there are few good universities and many interested students. Therefore, there is a national exam that all graduating high school seniors in the country take on a specific time and date. It is your rank in that exam that dictates your options—not only which university you will attend but what field you will study. In the United States, students have more options in terms of universities. Therefore, as long as they study well in their high school, they can typically pursue their field of interest.

Q. Which conferences do you find especially relevant to your research? Which do you find the most beneficial to attend?

Yasamin: As with any multidisciplinary research area, finding the right conferences can be a challenge. Control conferences such as CDC and ACC are definitely relevant for research on cooperative sensor networks. As such, I have submitted to and attended almost all CDC and ACC conferences since I started working in this area. For my work that is more focused on issues such as motion planning in mobile networks, some of the robotics conferences, like ICRA or IROS, are

also relevant. If the emphasis of the work is more on communication and networking, I also consider communication conferences such as Globecom or ICC.

Q. What kinds of courses do you enjoy teaching at the University of New Mexico? How would you describe your teaching style?

Yasamin: I enjoy teaching courses in both communications and control. On the communication side, I teach a graduate course on wireless communications, where we mathematically characterize wireless channels and study methods for improving the speed and performance of wireless communication. On the control side, I have taught the first-year graduate course on linear systems several times. I have also taught networked control systems, which is a project-oriented class involving current research topics and trends in this area.

In terms of teaching style, I ask a lot of questions in class. For instance, if I am doing a derivation, I stop frequently and ask the students how we should proceed next. At the beginning of the semester, students are often too shy to actively participate. But once they realize I will not move on until they say something, they start participating. I find that this method is beneficial and fun for the students. It helps them stay awake and learn the material better. It is also more rewarding for me as an instructor when I see the students engaged.

Q. What are some of your interests outside of research and teaching?

Yasamin: I have to say that as a junior faculty, one barely has time for anything outside of work! I used to play piano as a kid and recently bought a piano for my home. If I can squeeze time for a hobby into my schedule, it would be playing piano. I also enjoy reading modern Persian poetry and hope to find more time for it. New Mexico is also a state with rich culture and history as well as great opportunities for outdoor activities. If we find any time, my husband and I enjoy exploring the "Land of Enchantment."

Q. Thank you for speaking with *CSM*!

Yasamin: You're most welcome.

DALE ULRICH

Q. What does the field of kinesiology encompass, and what is your personal expertise?

Dale: Kinesiology is the interdisciplinary study of human movement and physical activity. Common subdisciplines within kinesiology include biomechanics, exercise physiology, motor behavior (motor control and development), pedagogy, sports management and marketing, and sport and exercise psychology. Most faculty and graduate students doing research in motor behavior employ motion-capture systems frequently used in engineering and biomechanics. Motion-capture systems combined with electromyography (EMG) allow researchers in kinesiology to answer basic and clinical research questions. Provosts at the University of Michigan are always surprised when they learn about kinesiology and the diversity of research that is disseminated in these units and how frequently the faculty collaborate with scientists in biomedical engineering, physiology, psychology, neural science, and the schools of business and medicine. As a result, kinesiology is viewed as a model of interdisciplinary research. Undergraduate student enrollment in kinesiology departments at many universities has increased by 40% or more in the past decade.

Dale Ulrich and rider.

My personal expertise is in motor behavior and developmental disabilities, specifically, Down syndrome (DS) and autism spectrum disorders (ASD). Employing principles of complex systems theory and neuronal group selection theory, I am motivated to learn how motor behaviors emerge in infants and children who experience biological and cognitive constraints. An example of this goal is our continuing research on the significant delay in onset of walking in infants with DS. We have learned that leg strength and postural control act as control parameters for walking onset in DS, and we have successfully reduced the delay in walking onset from 24–26 months of age to 18–19 months of age by having parents train their infant, beginning at ten months of age, on a small motorized treadmill until independent walking emerges. Walking gait also improves


Bicycle equipped with rollers.

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