Dream Topic

Suppose that, at an early age, you were forced to choose a topic in science or engineering that you would spend your entire career on. To be safe, you might search for the "ideal" research topic—a topic that is immediately understandable by everyone, has inestimable value in the commercial sector, is accessible enough to allow modest progress with reasonable effort, involves interesting science and technology ranging from chemistry to mechanics, and is hard enough that it is highly unlikely that someone will solve the problem and declare the research area dead. This tall order is easily met by the most basic and ubiquitous of physical phenomena: friction.

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Friction has two faces. If you wish to avoid slipping and sliding, then increasing friction is the goal. If you wish to increase energy efficiency, then decreasing friction is needed. You can pick either side of the problem, and you'll never run out of challenges. Progress on either side of the problem can have immense commercial value. For control engineers, the problem of controlling motion in the presence of friction is a never ending challenge.

What makes friction so challenging? Like turbulence, friction is a highly nonlinear, emergent phenomenon, that is, a phenomenon with roots in nonlinear dynamics having extremely high dimensionality. Friction models range from atomic-scale physics-based models to macro-scale empirical models. Physics-driven research can use the latest atomic force microscopes to experimentally probe the contributing factors at the smallest scales, while, at larger scales, phenomenological and black box models can be constructed to mimic observed behavior. Small-scale physical insights can be valuable in suggesting

Contributors

Chul-Goo Kang (far right) with his wife Won-Hee, their daughter Da-yeong (a middle school student in Korea), and their son Brian (a junior at Cornell majoring in mechanical engineering).

Brian and Beatrice Armstrong sailing.

Jong Kim visiting the Railway Technical Research Institute in Japan.

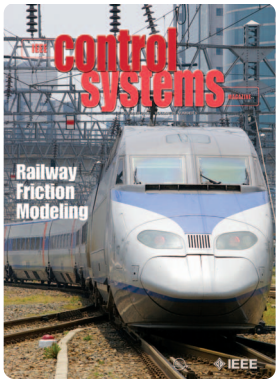
Nourdine Aliane on the campus of Universidad Europea de Madrid.

José Luis Guzmán with his wife Aurelia Ramírez in the Odeon of Herodes Atticus at the Acropolis of Athens, Greece.

the structure and parameters of large-scale empirical models, while empirical observations can be used to fine tune models for engineering applications.

Control practitioners must deal with the effects of friction to attain precision motion. Presliding friction—the forces generated before a body moves sizable distances—is also a two-edged sword. Stiction is valuable since it allows a body to remain in place against tiny perturbations, yet it makes motion control challenging since sticking and slipping make it difficult to achieve precise positioning. Consider the volume knob of a radio. A small amount of stiction makes it difficult to make tiny adjustments, yet without any stiction the knob would not remain where you set it. One "solution" to this problem is the use of détentes, as most of us know from a typical car radio. But this quantization solution limits resolution.

In this issue of *IEEE Control Systems Magazine* (*CSM*), we focus on friction modeling and its role in applications. This special section is due to the efforts of Warren Dixon of the University of Florida who serves as guest editor. The first article, by Sung Hwan Park, Jong Shik Kim, Jeong Ju Choi, and Hiro-o Yamazaki, considers the prediction and control of wheel slip in railway vehicles. Unlike rubber automobile tires on asphalt, the contact between metal railway wheels and metal rails entails slipping whenever the brakes are applied. Modeling and controlling this wheel slip is critical to braking performance and longevity.



The second article, by Jingang Yi, provides a detailed analysis of the wafer polishing process, which is critical to semiconductor manufacturing. The importance of this process is clear from the extensive analysis and experimentation that has been devoted to understanding the subtleties of this complex procedure.

The third and fourth articles are more theoretically oriented. The article by Brian Armstrong and Qunyi Chen provides a convenient approach to illustrating the types of physical phenomena captured by various friction models. The last article, by Ashwani Padthe, Bojana Drincic, JinHyoung Oh, Demosthenis Rizos, Spilios Fassois, and myself, has an analogous but narrower goal, where the focus is on the hysteretic properties of various friction models.

For the "Applications of Control" column, Chengliang Liu, Mingjun Wang, and Jun Zhou describe the development of a tractor whose wheels can be independently steered, thus allowing maneuverability that is not achievable by standard vehicles. This department also includes an article by Chul-Goo Kang, who describes the development of a robotic arm that arm wrestles and is kind enough to reward the efforts of its opponents.

Additional highlights of this issue include a response by Kris Hollot to a query about the use of feedback in reducing congestion on the Internet, as well as a tutorial article on PID control by J.L. Guzman, K.J. Astrom, S. Dormido, T. Hagglund, M. Berenguel, and Y. Piguet. Along the same lines Nourdine Aliane describes a spreadsheet-based control design and education tool. Education is also highlighted by Malcolm Shuster's article on advice for young researchers, which will surely be of interest to experienced researchers as well.

And that is not all. This issue includes standard columns such as "25 Years Ago," "Technical Committee Activities," "President's Message," "Member Activities," "Bookshelf," and "Conference Reports" as well as an extended "People in Control" column, which includes two interviews along with recognition of 13 2008 IEEE Control Systems Society (CSS) Fellows and six new *CSM* associate and corresponding editors. Congratulations to the Fellows, and welcome to the new board members!

In this issue we also remember Michael Rabins, who left an indelible mark on our field, especially on the enterprise of education.

The issue concludes with a rather unusual application of the CSS logo.

I hope that the excellent contributions to this issue motivate you to contact me about your ideas for future articles for *CSM*. You might have noticed that all *CSM* articles are in full color and, unlike other *CSM* publications, there are no page charges—at any length. This policy recognizes that *CSM* articles provide a valuable service to the CSS community.

Although this issue of *CSM* has no letters, I encourage you to contact me with your comments on any aspect of this magazine, or the control field in general. As CSS President David Castanon likes to say, *CSM* is a conversation about the field. Feel free to speak up!

Dennis S. Bernstein

Kris Hollot, his wife Wendy (standing), and daughters Andrea and Erica. Not present for the picture was their son Nicholas.

Jingang Yi and his son Joshua.