Global Viewpoint

Think about pointing for a minute. Visualize yourself at the center of a sphere, where each direction can be associated with a point on the sphere. Now, imagine that the device that performs the pointing is a double gimbal mechanism, the ubiquitous device that can pitch and yaw by rotating about a pair of single-axis joints. Your goal is to control the mechanism to change the direction of pointing from the current direction to a new, specified setpoint.

The double gimbal mechanism was the focus of the February 2008 issue of *IEEE Control Systems Magazine* (*CSM*), which was devoted to inertially stabilized platform technology. The articles in that issue describe numerous practical and theoretical issues that arise in implementing inertially stabilized platforms. Control of these systems is challenging for a vast number of reasons, ranging from base disturbances to gimbal lock.

When large-angle motions are considered, two additional issues must be considered. First, the shortest path connecting two points on the sphere might not correspond to a shortest path in terms of the motion of the gimbals. In addition, the gimbals are coupled to each other, and the gimbals and payload have mass properties that affect the amount of force and energy needed to perform the maneuver.

The first feature article in this issue complements the articles in the February issue by providing deeper insights into the kinematics and dynamics of the double gimbal mechanism. The problem of determining the required paths of the gimbals is analyzed by viewing the kinematics of the double

Contributors
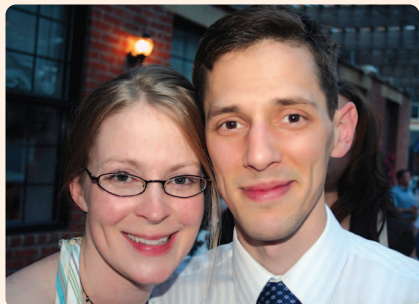
Eric and Betsy Westervelt

Jason Osborne hiking in Ireland.

Roberta Bruzzone



Greg and Brandi Hicks

Marco Strano

Rob and Stephanie Fuentes at the Matanuska glacier in the Alaskan interior.

gimbal mechanism in terms of curves on the surface of a donut-shaped torus, where distances are measured by means of a metric that accounts for the mass properties of the gimbals.

The torus is a manifold, and the curves of shortest distance are geodesics. These concepts depend on global analysis, which is a subject of deep mathematical power and beauty. As an example of this power, consider the concept of holes in a manifold. These holes, which are characterized by the Betti numbers of the manifold, provide intuitively compelling insight into the obstructions to performance and global stabilization—just as a hole in a road necessitates an inconvenient but unavoidable detour.

Kelli Baumgartner

Silvia Ferrari with her husband John and their son Sean.
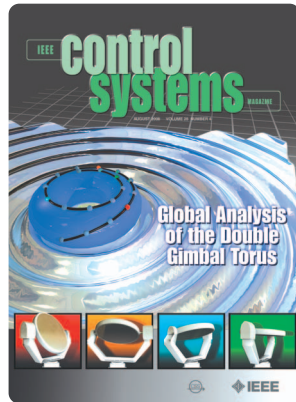
The article by Jason Osborne, Gregory Hicks, and Robert Fuentes provides a novel exposition of the double gimbal mechanism in terms of global analysis. Their article thus serves a dual purpose, namely, by providing deeper insights into the kinematics and dynamics of the double gimbal mechanism relevant to control, and by providing a tutorial introduction to the concepts of global analysis. The latter goal is achieved in a unique way in the sense that the introduction is set fully within the context of a specific system of direct interest to control system engineers.

The second feature of this issue, by Silvia Ferrari, Kelli Baumgartner, George Palermo, Roberta Bruzzone, and Marco Strano, uses data-based modeling techniques to extract hidden relationships from data. The specific application is criminal investigation, where the goal is to use values of a few variables to infer values of other variables. Their techniques uncover relationships that have been overlooked by expert investigators using traditional profiling methods.

The last feature, by Bruno Teixeira, Mario Santillo, Scott Erwin, and myself, is a tutorial application of Kalman filter techniques to the problem of orbit estimation. The goal is to use as few measurements as possible to locate and track a satellite in orbit around the Earth. The sampled-data estimation problem is addressed by using the classical extended Kalman filter as well as the unscented Kalman filter, which can be viewed as a particle or sigma-point filter. The results show that nonlinear state estimation can be a challenging problem, especially in the vicinity of an unobservable initial state.

Among the columns that this issue brings you is a detailed description of recent advances in data storage. This "Applications of Control" column by Abu Sebastian, Angeliki Pantazi, Haris

Pozidis, and Evangelos Eleftheriou provides considerable insight into the ingenuity of control engineers in developing methods for accurately and efficiently storing and reading data from increasingly dense media.

For the "Ask the Experts" column, the expert for this issue is Eric Westervelt, who has extensive experience with two-legged robots. Eric answers the question that we've all wondered about: Why is it so hard to build and control a robot that can walk on two legs? His answer makes us appreciate even more a basic human skill that most of us take for granted.

"People in Control" includes interviews with three IEEE Control Systems Society (CSS) members—Claire McCullough, Bojan Grcar, and Paul van den Bosch—who have reached the 25-year milestone in their CSS memberships. We ask each of them to talk about their career goals and accomplishments as well as the benefits they've received as members of CSS.

For "Focus on Education," Malcom Shuster explains how ambiguity in the arts can be valuable to the engineering profession. His views emphasize the distinction between deductive reasoning—where we apply methods to solve a well-defined problem—and inductive reasoning, where we apply intuitive (for lack of a better word) "reasoning" to take creative steps toward problem definition and new ideas.

This issue also brings you "25 Years Ago," David Castañón's latest "President's Message," "Feedback," "Member Activities," "Technical Committees," and book reviews. There's a lot to take in. Enjoy.

For the rest of 2008 we have all of the usual columns as well as features on formation control and friction. Lots of friction. After that, the horizon includes articles on hysteresis and, of course, Kalman filtering. If you have something that you'd like to write about, please contact me. *IEEE CSM* is a great venue for sharing your work and ideas with the control community.

Dennis S. Bernstein