

Quieter Clocks

Although it's not immediately evident, one of the most useful things to have if you wish to find out where you are is a clock. If you're on a ship somewhere on the ocean, where maps are not especially useful, you could check what time it is when the sun is directly overhead. If your clock is set to the time back home,

then the time difference can tell you how far east or west of home you are. This navigation technique was one of the great motivations for developing better clocks in the days when ships with sails explored the globe and the consequences of not knowing location were dire.

In modern times, clocks tell us where we are in an analogous way. By receiving time-stamped, radio-frequency

signals from multiple transmitters, the times of arrival can be used to deduce location. This scheme works if the speed of radio-wave propagation is constant and no delays are present in the system, which unfortunately is not exactly the case but good enough for many applications.

Since a clock is a regulator, building better clocks is a control problem. Like many control problems, how well

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Contributors



Jess and Kandler Smith with their daughter Adelaide.



Kandler and Adelaide Smith.



Yanniss Schizas enjoying the sun in Aruba.

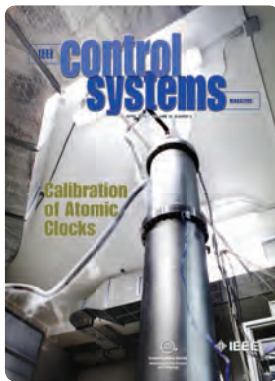


Georgios Giannakis.



Ilenia Tinnirello and her husband Giuseppe Gargagliano in Rome.

a clock—or any control system—operates depends on many facets of the technology, such as nonlinearities, uncertainty, and noise. These facets interact in complicated ways to define the accuracy and precision of a clock and thus our ability to determine location.



depends on understanding the nature of this noise and developing techniques to reduce its effect.

The article by Lorenzo Galleani and Patrizia Tavella shows that systems and control techniques are crucial for improving the accuracy of atomic clocks. The objective is to combine

Modern clocks are based on sine waves arising from atomic processes, and the main task is simply to count oscillations by determining zero crossings. But these sine waves are not perfect; in fact, their phase fluctuates ever so slightly in a random manner, which constitutes clock noise. The ability to improve the accuracy of a modern clock thus

the measurements of multiple clocks to obtain a time estimate that is more accurate than any single clock can provide alone. Least squares techniques, including variants of the Kalman filter, are the basis of this work.

As another application of estimation techniques, the article by Ilenia

Tinnirello and Giuseppe Bianchi seeks to reduce the occurrence of message collisions in communications networks. Focusing on Wi-Fi networks, each contending station estimates the number of stations and the channel error rates in a decentralized manner. These estimates allow the network to more efficiently utilize the available communication bandwidth.

Along the same vein, the article by Alejandro Ribeiro, Ioannis Schizas, Stergios Roumeliotis, and Georgios Giannakis is concerned with estimating location by using extremely limited data, for example, only the sign of the measurement. The goal is to minimize the amount of data transmitted and thereby hardware and network costs. This goal necessitates the development of unconventional estimation techniques.



Giuseppe Bianchi.



Stergios Roumeliotis.



Alejandro Ribeiro with his daughter Miranda at her graduation from elementary school.



Patrizia Tavella.



Ilaria and Lorenzo Galleani with their son Gabriele.

Taken together, these features continue the series of special articles on applications of Kalman filtering. Previous special sections include the articles on data assimilation in the June 2009 issue as well as the articles on Kalman filter applications in the December 2009 issue. Along with the temperature-estimation article in the February 2010 issue, a dozen feature articles on Kalman filter applications have now been published in recognition of the 50th anniversary of this variation of recursive least squares optimization.

Complementing these feature articles is another article, in the “Historical

Perspectives” column, in the reminiscences series. The latest installment is a composite article by students of Rudolf Kalman, who describe their learning experiences in the systems research center at the University of Florida.

This issue of *IEEE Control Systems Magazine* also brings you an “Applications of Control” column on the use of model-based techniques for estimating the state of a lithium-ion battery, thus facilitating more efficient use of these components. For “People in Control,” we speak with Bill Garrard and Asen Dontchev, who work on problems in aerospace engineering and optimal control, respectively. In addition, we

have one book review, several book announcements (be sure to check out the latest publications), and several conference reports. We also remember Richard “Dick” Saeks, who contributed to the control field and many others as well.

IEEE Control Systems Magazine publishes letters on any aspect of this magazine or systems and control in general. Your letters are welcome. Technical contributions, either long or short, are welcome as well. I look forward to hearing from you.

Dennis S. Bernstein



Planning for the Future

2010 ACC

Baltimore, Maryland, USA

2011 ACC

San Francisco, California, USA

2012 ACC

Montreal, Canada

2013 ACC

Washington, DC, USA

2010 MSC

Tokyo, Japan

2011 MSC

Denver, Colorado, USA

2012 MSC

Dubrovnik, Croatia

2013 MSC

Hyderabad, India

2014 MSC

Nice, France

2010 CDC

Atlanta, Georgia, USA

2011 CDC

Orlando, Florida, USA

2012 CDC

Maui, Hawaii, USA

2013 CDC

Venice, Italy

Leader of the Expedition

Every course has its winter of discontent—those times when most students are just struggling along, not really seeing where things are headed, and feeling they will never get any mastery. It’s up to you to cheer them on, to reassure them that others have made it and they can too. Point out some of the natural wonders in the distance, and the pitfalls you’re leading them past. Teach them survival skills. Hold up to them visions of the delights that await them on the summit.

OK, block that metaphor. All the same, a little of your energy and enthusiasm supplied at the right moment can give them the lift that will take them the rest of the way.

—Arthur P. Mattuck, *The Torch or the Firehose, a Guide to Section Teaching*, M.I.T., 1981, 1995, p. 26.