Friendship, Leadership, and Scholarship in Australian Slang

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https://fbullo.github.io

BobFest

Career with Cheer: Robert Witmead's Legacy of Control and Selflessness

Bob the Leader

University of California San Diego, June 8, 2024

SEMINAR

UNIVERSITY OF CALIFORNIA, SAN DIEGO
MECHANICAL & AEROSPACE ENGINEERING

Data-Driven Control Design People. You're Just No Fun Anymore!

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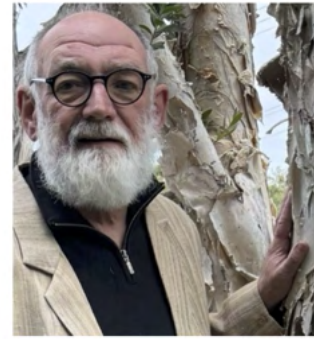

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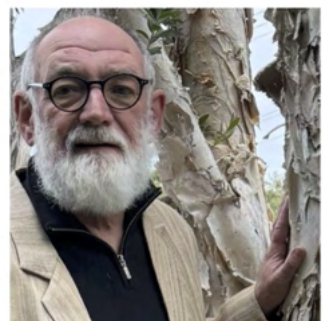


Data-Driven Resilient Predictive Control Under Denial-of-Service

Wenjie Liu, Jian Sun, *Senior Member, IEEE*, Gang Wang, *Member, IEEE*, Francesco Bullo, *Fellow, IEEE*, and Jie Chen, *Fellow, IEEE*

***Abstract*—The study of resilient control of linear time-invariant (LTI) systems against denial-of-service (DoS) attacks is gaining popularity in emerging cyber-physical applications. In previous works, explicit system models are required to design a predictor-based resilient controller. These models can be either given a priori or obtained through *a priori* system identification step. Recent research efforts have focused on data-driven control based on precollected input–output trajectories (i.e., without explicit system models). In this article, we take an initial step toward data-driven stabilization of LTI systems under DoS attacks, and develop a resilient model predictive control scheme driven purely by data-dependent conditions. The proposed data-driven control method achieves the same level of resilience as the model-based control method. For example, local input-to-state stability (ISS) is achieved under mild assumptions on the noise and the DoS attacks. To recover global ISS, two modifications are further suggested at the price of reduced resilience against DoS attacks or**

I. Introduction

THANKS to recent advances in computing and networking technologies, recent years have witnessed rapid developments in cyber-physical systems (CPSs), e.g., [1], [2], [3], [4], [5], [6]. Nonetheless, it has been reported that such systems are often vulnerable to cyber-attacks [7], [8], including false-data injection attacks [9], [10], replay attacks [11], and denial-of-service (DoS) attacks [12]. For instance, on February 8, 2020, the telecommunication network of Iran suffered from DoS attacks for about an hour [13]. As a consequence, 25% of the national Internet connection dropped, leading to severe damage of critical infrastructure as well as significant economic loss. In general, DoS attacks require little knowledge about the system and are therefore easy to be implemented. Moreover, DoS attacks are destructive. If an unstable open-loop process adopts a remote controller, then a long duration of DoS may confer irreparable

Data-Driven Self-Triggered Control via Trajectory Prediction

Wenjie Liu, Jian Sun, *Senior Member, IEEE*, Gang Wang, *Member, IEEE*, Francesco Bullo, *Fellow, IEEE*, and Jie Chen, *Fellow, IEEE*

***Abstract*—Self-triggered control, a well-documented technique for reducing the communication overhead while ensuring desired system performance, is gaining increasing popularity. However, a majority of existing self-triggered control methods require explicit system models. An end-to-end control paradigm known as data-driven control designs control laws directly from data and offers a competing alternative to the routine system identification-then-control strategy. In this context, the present article puts forth data-driven self-triggered control schemes for unknown linear systems using input–output data collected offline. Specifically, a data-driven model predictive control (MPC) scheme is proposed, which computes a sequence of control inputs while generating a predicted system trajectory. In addition, a data-driven self-triggering mechanism is designed, which determines the next triggering time using the solution of the data-driven MPC and the newly collected measurements. Finally, both feasibility and stability are established for the proposed self-triggered controller, which are validated using a numerical example.**

***Index Terms*—Data-driven control, data-driven model predictive**

proposed, including e.g., reinforcement learning-based control [3], model-free control [4], and extremum seeking control [5]. More results on data-driven control can be found in [6]. Most recently, the result of fundamental lemma in [7] has attracted reviving interest. This lemma provides a nonparameteric representation of a linear time-invariant system using a trajectory of the system. Inspired by this work, a number of applications and generalizations have been made, including stabilization and optimization [8], [9], [10], linear quadratic regulation [11], robust control [12], quantized control [13], model predictive control (MPC) [14], [15], [16], [17], consensus control [18], [19], and control of complex networks [20].

Yet, the aforementioned works employ periodic transmission protocols, which may be resource inefficient for real-world systems in terms of processor usage, communication bandwidth, and energy. In cyber-physical networked systems [21], for instance, whose communication network is shared by many devices, the communication bandwidth is al-

Jan and Bob The Hosts

July 4, 2007

Jan and Bob The Hosts
July 4, 2007

Bob The Master of Ceremony
May 28, 2009

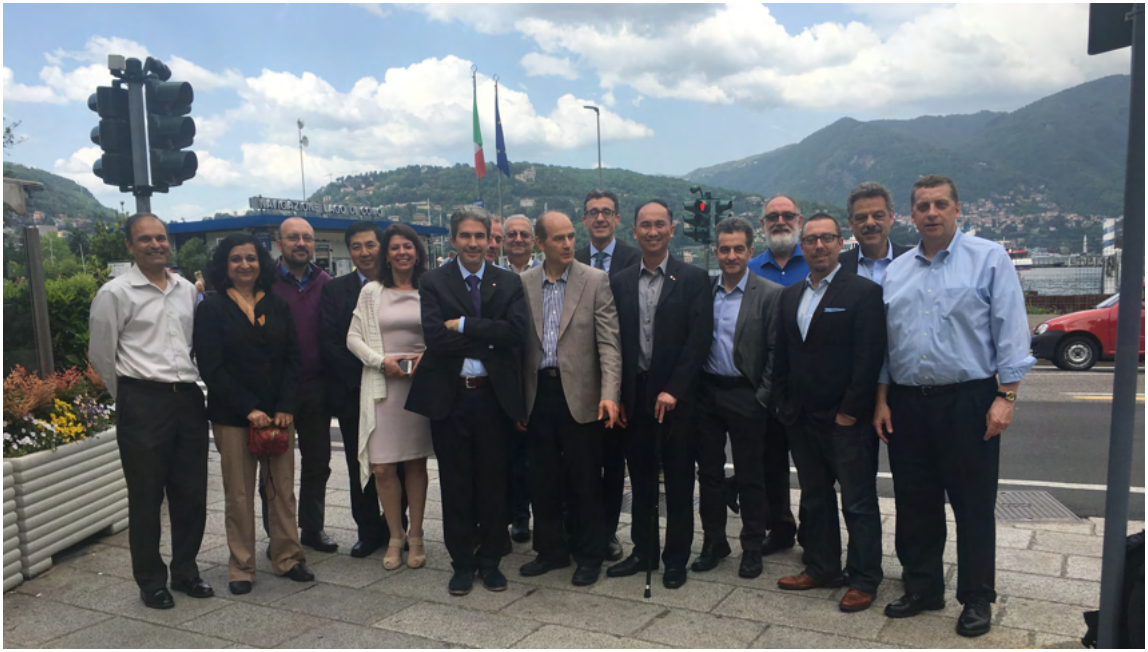
Bob The Leader

IEEE CSS Vice-President for Financial Activities 2015-16

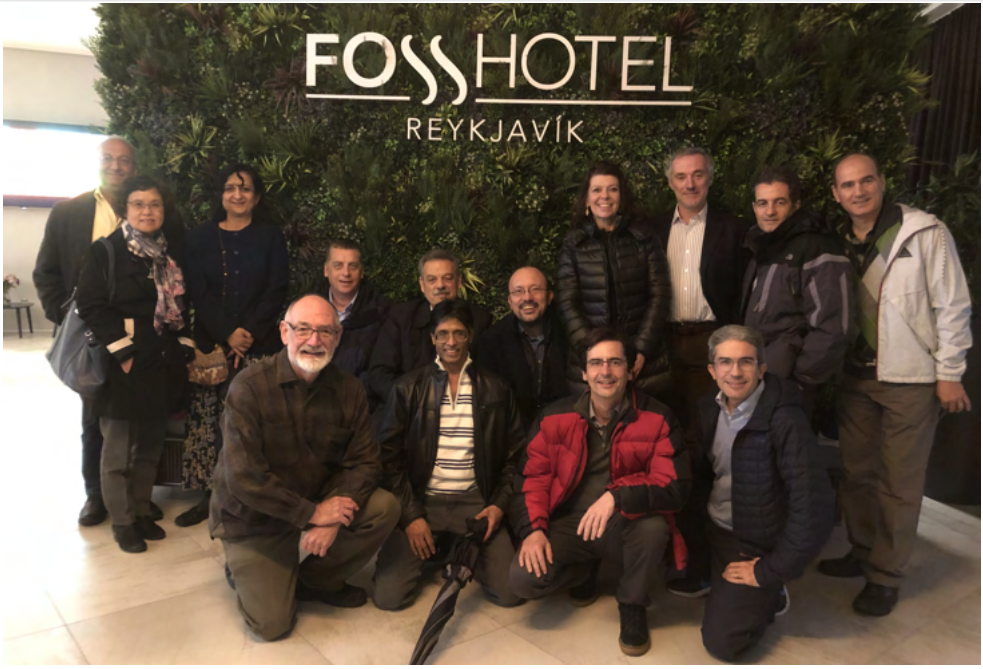
President Elect in 2018, President 2019, and President Past 2020

Taipei, oct 2017, ExCom meeting

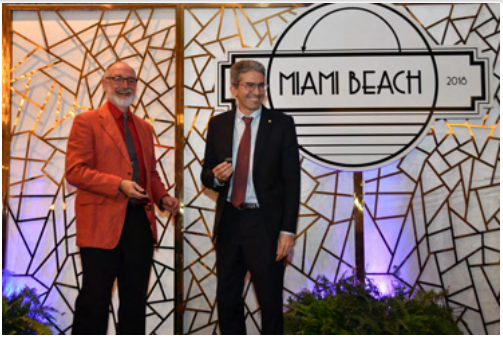
Como, may 2018, ExCom meeting

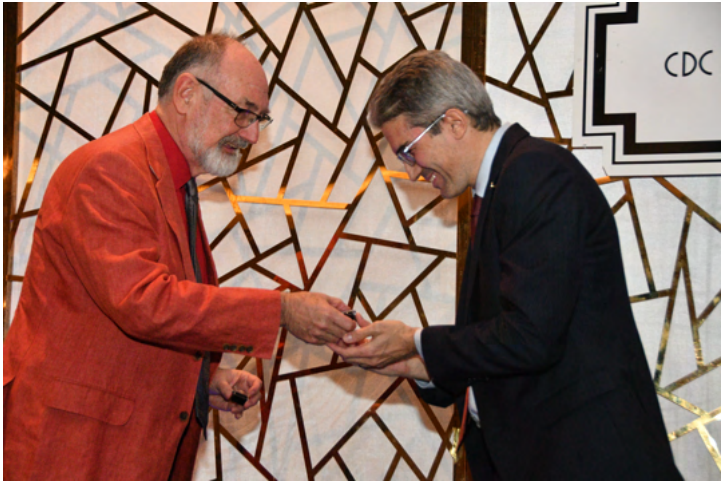


Reykjavik, may 2019, ExCom meeting



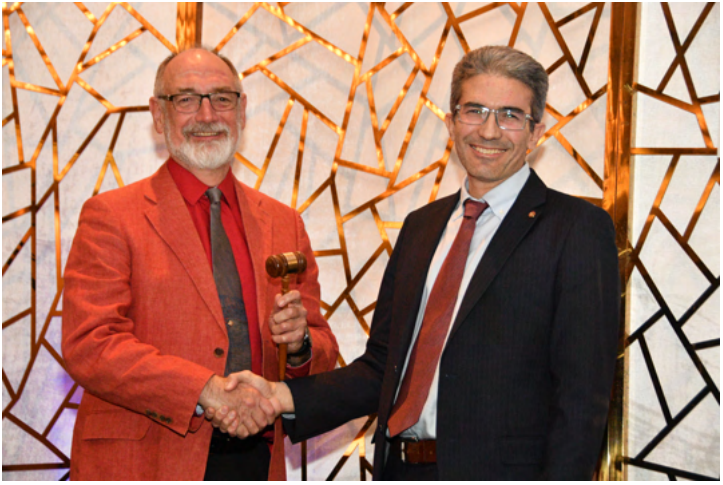
Miami Beach, dec 2018 — finally coming into CSS absolute power





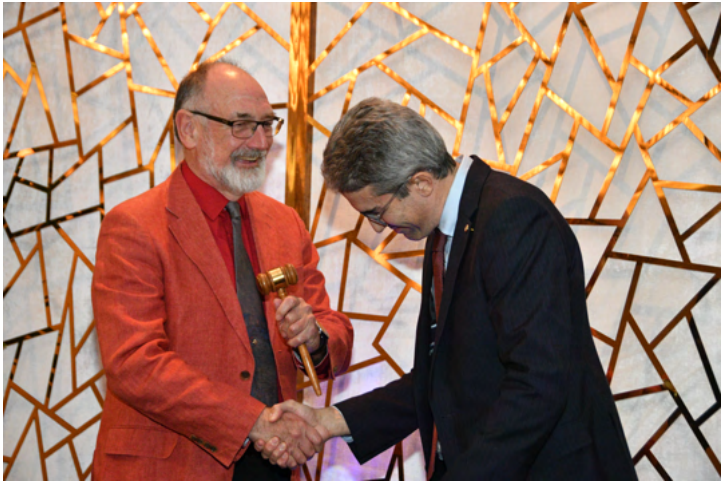
Exchanging cerimononial pins

About the IEEE CSS Presidential Gavel



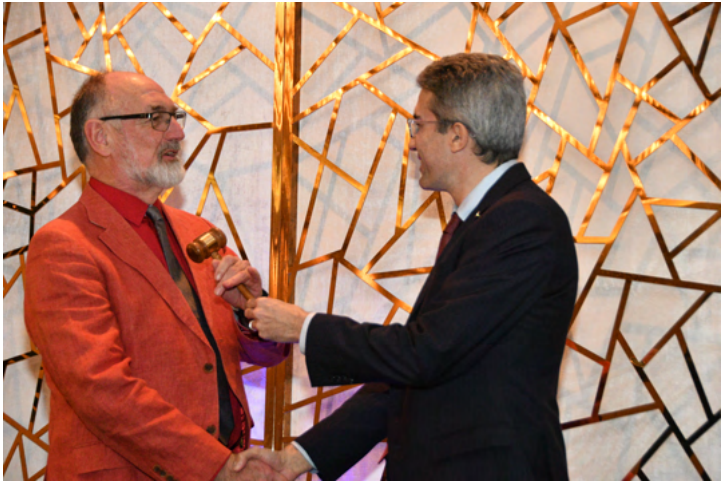
Bob happy with his new toy

About the IEEE CSS Presidential Gavel



looking at the precious gavel one last time

About the IEEE CSS Presidential Gavel



Bob defending his gavel

About the IEEE CSS Presidential Gavel

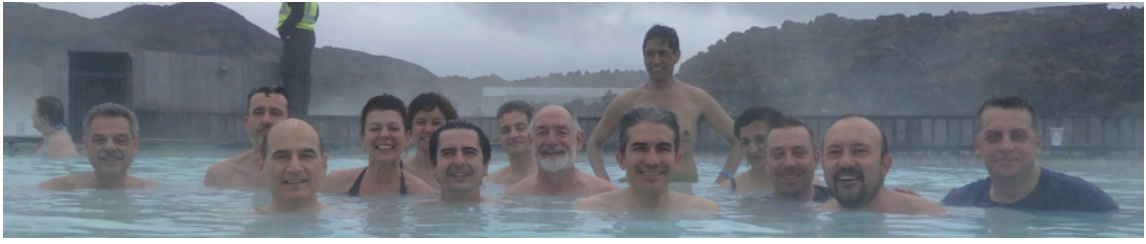
Bob giving me a fake one

Bob passing on his gavel to Anu

Three main achievements as CSS President

In reverse importance order:

1. IEEE Open Journal of Control Systems
2. L-CSS for American Control Conference
3. IEEE Control Systems Society Fund
4. Two-year CSS presidency
5. ...



deep respect and gratitude

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But ... don't be fooled ... appearances can be deceiving and not all that glitters is gold

deep respect and gratitude

But ... don't be fooled ... appearances can be deceiving
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strine = the English language as spoken by Australians

selected highlights

1. clayton
2. the dingo's breakfast
3. drinking lizards


PRESIDENT'S MESSAGE

A Clayton's Regime Change

Clayton's is “the drink” you have when you are not having “a drink.” It is a nonalcoholic drink base or cordial. The expression comes from a television marketing campaign in Australia and New Zealand from the 1970s and featured rugged actor Jack Thompson. Since the IEEE Control Systems Society (CSS) is deliberately and decidedly international, I have chosen to embark on my first *IEEE Control Systems Magazine* “President's Message” with this piece of Antipodean vernacular, which has come to capture the idea of being either a poor substitute or effectively the same thing. I am hoping for the latter interpretation, by which I seek to continue the sequence of capable and imaginative CSS presidents whom I follow and whose careful and thoughtful guidance has brought us this far. I learned a lot from my predecessors as I operated in a number of capacities for CSS over the years. Perhaps I should have been a touch nerdier or apropos and said that I expect a *bumpless transfer*.

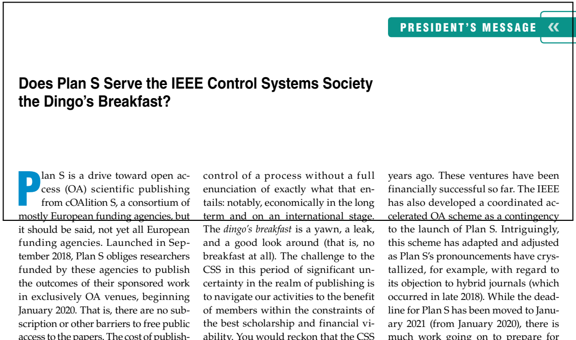
It is, indeed, an honor to take the reins—but not the reigns—of the CSS for 2019 and manage our evolution in

eral countries with highly divergent organizations, such as academia, many industry sectors, government, and defense laboratories. This experience allows me to appreciate how organizations deliver on their objectives within their structural constraints. I hope to bring a big-picture view to the job and benefit from the expansive reach of the management team.

Bumpless transfer does not entail the absence of change, especially as our context and operating milieu alter around us. The CSS is in great shape—no need to “make CSS great again.” Finances are very healthy because of the success of our technical powerhouse publications and conferences. Demand for control professionals is very strong across a great many industries and sectors. Modeling, estimation, and control underpin the technological response to many central human and environmental challenges, notably in climate, energy, biotechnology, medicine, and transportation and their knock-on effects to other activities, especially in automation in general. However, there are definite areas in which we, the CSS, can improve, lift

rigorous downbeat reviews given to grant proposals within the control area were perceived as symptomatic of a field in decline. Look at us now!

The response from those early days was to promote the area more forcefully and capture the public's imagina-


PRESIDENT'S MESSAGE

Does Plan S Serve the IEEE Control Systems Society the Dingo's Breakfast?

Plan S is a drive toward open access (OA) scientific publishing from cOAlition S, a consortium of mostly European funding agencies, but it should be said, not yet all European funding agencies. Launched in September 2018, Plan S obliges researchers funded by these agencies to publish the outcomes of their sponsored work in exclusively OA venues, beginning January 2020. That is, there are no subscription or other barriers to free public access to the papers. The cost of publish-

control of a process without a full enunciation of exactly what that entails: notably, economically in the long term and on an international stage. The *dingo's breakfast* is a yawn, a leak, and a good look around (that is, no breakfast at all). The challenge to the CSS in this period of significant uncertainty in the realm of publishing is to navigate our activities to the benefit of members within the constraints of the best scholarship and financial viability. You would reckon that the CSS

years ago. These ventures have been financially successful so far. The IEEE has also developed a coordinated accelerated OA scheme as a contingency to the launch of Plan S. Intriguingly, this scheme has adapted and adjusted as Plan S's pronouncements have crystallized, for example, with regard to its objection to hybrid journals (which occurred in late 2018). While the deadline for Plan S has been moved to January 2021 (from January 2020), there is much work going on to prepare for


PRESIDENT'S MESSAGE

Like a Lizard Drinking

The governance side of the IEEE Control Systems Society (CSS) is where the administrative CSS machine is maintained, greased, and occasionally refurbished. The heart of the beast is the Executive Committee (*ExCom* for the epithetically gifted) comprising the president (yours truly), past-president (Francesco Bullo), president-elect (Anu Annaswamy), director of Operations (DoO) (Jorge Cortés), and the vice presidents for Technical (João Hespanha), Financial (Jing Sun), Pub-

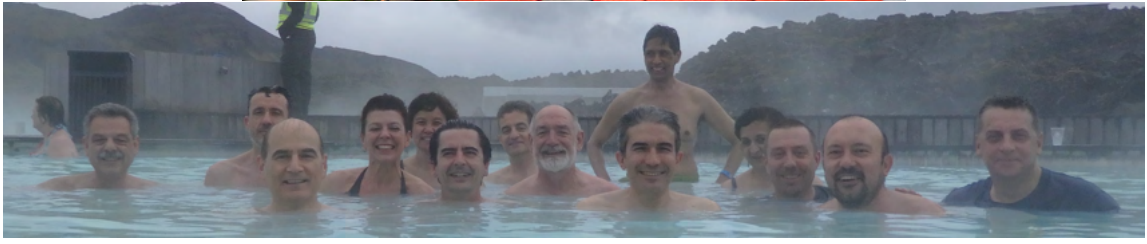
Why bring this up now, when we could have skipped to the funnies inside the back cover? Well, at the time of writing (June), the midyear biannual BoG meeting is coming up at the American Control Conference in Philadelphia. At the time of publication, it will be over. So this is a time of great work behind the scenes. The ExCom is *flat but like a lizard drinking*: preparing materials and vetting proposals for consideration by the BoG. In mid-May, the ExCom (together with the editors-in-chief) met for two days

was seen in the absence of articles about control in, say, *IEEE Spectrum*. A working group was formed without remarkable success. More recently, in 2014, “The Impact of Control Technology, Second Edition” (see ieeecss.org/general/IoCT2-report) was curated by Tariq Samad and Anuradha Annaswamy as a sequence of two-page flyers: “Success Stories for Control” and “Challenges for Control Research.” The breadth of activity and impact is impressive. What a difference 30 years makes!

Still, we struggle with the 30-s elevator pitch or even the innocent question from one's children about what do you do at work. Control is hard to describe and possesses a barrier to entry, which, at best, yields some celebrity status to the control engineer on site. In 2014, I delivered an after-dinner

and initiatives run by the volunteers. The interface with the IEEE also falls to the ExCom, which serve as conduits of policy and capability from the IEEE headquarters. Of course, this covers the gamut of the CSS activity.

The IEEE is governed by boards and committees also largely populated by volunteers but not “so on ad infinitum.” Authority stops at the IEEE Board of Directors, who are volunteers trickling up from the Societies, for example, CSS past president Steve



Happy birthday and congratulations!