stability. New insights from data-based learning (such as concurrent learning and experience replay) and state extrapolation (that is, simulation of experience) are shedding light on less stringent (finite and online verifiable) excitation conditions for simultaneous control and parameter identification. Actor-critic-based reinforcement learning and Q-learning methods are emerging as approaches to yield approximate optimal control in the presence of uncertainty. Foundational pillars have been established by the switched and hybrid systems control communities that open new opportunities for adaptive systems in the presence of intermittent feedback, communication, and/or sensing. Formal methods have also been established to provide some verifiable task completion, but new questions arise when considering the integration of formal and learning methods.

Answers to such new theoretical domains can have an impact on a wide range of new applications. Cybereffects can be injected in control systems as an apparent change in the dynamics, sensing, and control influence, where emerging methods in system identification can potentially lead to new cyberdefense or forensics tools. Government and industrial sectors are heavily investing in a variety of applications where (semi-)autonomous systems are tasked with operating in complex environments (such as automated driving and military applications) where sensing/feedback may be uncertain, denied/intermittent, or attacked/spoofed. Numerous questions for intelligent control arise in such applications, especially when incorporated with a human operator. Such applications have resulted in large-scale investments in programs generally described as “autonomy,” where the (surface-level) impression is that progress will result from advancements in artificial intelligence (AI). TC-IC has a long history of building bridges between the rigorous mathematical approaches of the control systems community with the insights from computational intelligence/AI to yield intelligent control systems with predictable behaviors.

Intelligent control is well poised to answer many of the open challenges facing autonomous systems. As a result, TC-IC has expanded its roster to approximately 100 members, with much of the growth due to young professionals, including assistant and associate professor-level faculty members and numerous students. TC-IC has been active in promoting invited sessions, workshops, and special issues in journals in recent years (such as approximate/adaptive dynamic programming for control of cyber-physical systems, recent advances and future directions on adaptation and control, autonomy and machine intelligence in complex systems, intelligent control in discrete-time for autonomous systems, and deep reinforcement learning and adaptive dynamic programming), along with disseminating recent advances through various invited lectures, IEEE Distinguished Lectures, and semiplenary and plenary talks. Researchers interested in further information about intelligent control or who would like to join TC-IC are welcome to contact the TC chair. The TC website can be found at http://www.ieeecss.org/technical-activities/intelligent-control, which provides a listing of TC-IC members and their activities.

Warren Dixon

IEEE Technical Committee on Aerospace Control

Aerospace vehicles have continued to provide a stimulating set of challenges as well as veritable testbeds for demonstrating the utility of advanced control algorithms. The integration and fielding of a variety of aerospace systems driven by sophisticated control algorithms are a bright spot in our ongoing conversation about the lack of adoption of advanced controls by industry. Members of the Technical Committee on Aerospace Control (TC-AC) have contributed to some of the recent successes of aerospace control. Notable among these are: 1) the use of robust adaptive control for flight demonstration of the Phantom Eye high-altitude, long-endurance unmanned aerial vehicle, which earned TC-AC member Kevin Wise of Boeing the inaugural IEEE Control Systems Society (CSS) Award for Excellence in Aerospace Control (Figure 1); 2) flight control algorithms on the exploration flight test 1 of the Orion Spacecraft (Figure 2), which completed two orbits around the earth; and 3) an L₁ adaptive control demonstration using the F-16 Variable In-flight Stability Test Aircraft (VISTA), performed by a team from the University of Illinois at Urbana-Champaign and the U.S. Air Force Test Pilot School (Figure 3).
TC-AC consists of IEEE CSS members from academia, government, and industry working together to promote the advancement of technology and the knowledge of control systems for aerospace vehicles. To foster personal development, the TC recently started an initiative to match qualified members with more senior colleagues to help them navigate the elevation process to IEEE Senior Member or Fellow, resulting in three recent elevations to IEEE Senior Member and one Fellow nomination in process. Another manner in which we promote aerospace controls is through the CSS Award for Technical Excellence in Aerospace Control awarded at the IEEE Conference on Decision and Control (CDC). Nominations are due to the CSS Awards Committee each year by May 15. Please see http://www.ieeecss.org/awards/award-technical-excellence-aerospace-control for more details.

TC-AC currently has 50 members, which consists of six IEEE Fellows, 13 IEEE Senior Members, and 31 IEEE Members (Figure 4). Because TC-AC brings together government, academia, and industry, we have the unique opportunity of enriching and complementing activities in our respective organizations. TC members from government are able to educate colleagues about research funding opportunities. Members from industry discuss new problems they are facing and what challenges academia must consider to conduct relevant research and prepare students to thrive in the workplace. Colleagues in academia discuss collaboration opportunities and familiarize industry members with new and emerging research.

The TC’s technical activities include special issues in CSS publications and invited sessions at conferences. A recent example is the session “A Spacecraft Benchmark Problem for Analysis and Control of Hybrid Systems,” organized by Scott Erwin of the Air Force Research Lab (Figure 5). The TC also organized a very successful workshop,
“Guidance, Navigation, and Control (GNC) Applications in the Aerospace Industry: Current Problems and Modern Solutions” at the 2017 Conference on Control Technologies and Application (CCTA) in Hawaii (Figure 6). The workshop covered relevant industry topics in GNC for manned and unmanned aircrafts, guided missiles, space launch vehicles, satellites, and precision-guided projectiles. Presenters were all TC members from industry and academia: Richard Hull (UTC Aerospace Systems), Kevin Wise (Boeing), Brett Ridgely (Raytheon), Naira Hovakimyan (University of Illinois), Gokhan Inalhan (Istanbul Technical University), Zhihua Qu (University of Central Florida), and Wen-Hua Chen (Loughborough University).

Looking to the future, we are focusing on two main initiatives centered on engaging the controls community in aerospace-related problems and attracting more undergraduate and graduate students to the exciting world of aerospace controls. To engage the community, we are creating an aerospace control challenge problem that will galvanize contributions from a variety of disciplines to determine a solution. Our aim is to expose students and researchers from a variety of backgrounds to aerospace control. This will also include sponsoring a selected number of undergraduate students to attend CSS conferences to soak in the atmosphere!

We coordinate our activities via a quarterly teleconference and in-person meetings at the ACC, CDC, and/or CCTA each year. Please see our website for more information: http://aerospace-controls.iede.css.org/. Any IEEE CSS member can join the TC-AC. Please e-mail me at Kingsley.fregene@lmco.com if you wish to join the TC or need more information.

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