Technical Committee on System Identification and Adaptive Control

The main goal of the IEEE Control Systems Society (CSS) Technical Committee on System Identification and Adaptive Control (TC-SIAC) is to coordinate the activities of TC members that relate to the development of innovative theoretical and technical solutions in the scientific areas of system identification and adaptive control. Figures 1 and 2 provide good illustrations of the importance of SIAC in numerous engineering fields.

In a nutshell, the TC-SIAC activities are mainly related to the following keywords: data-driven modeling, iterative learning control, learning rules for prediction, control and optimization, model selection, tracking and adaptation, model validation, fault detection, and experiment design. More specifically, TC-SIAC helps its members to promote and organize numerous 1) invited sessions during the major control conferences, 2) preconference workshops on all theoretical and practical aspects of data-driven modeling and adaptive control, and 3) publications of special issues and book chapters on related topics. Restated, the main goals of the TC-SIAC are to

- create new opportunities for technical discussions among TC members with specific attention given to emerging research needs and directions
- provide technical resources (such as the new mailing list tcsiac@ieeecss.org) to promote new initiatives and research interactions among TC members
- disseminate relevant information to TC members and other students/researchers in industry.

TC-SIAC has 74 active CSS members at all grade levels of IEEE membership, including several associate editors and numerous members of the CSS Conference Editorial Board. TC-SIAC has held meetings during past American Control Conferences (ACCs) and the IEEE Conferences on Decision and Control (CDCs). The interaction between our TC members and other control federations [such as the International Federation of Automatic Control (IFAC)] is very strong, as shown by the involvement of several TC members in the IFAC TC 1.1 (Modeling, Identification, and Signal Processing) and by their role as associate editors of leading IFAC journals.

RESEARCH EXAMPLES

A joint research team of Centrale Supelec and ITMO University, led by Alexey Bobtsov and Romeo Ortega, has proposed a new procedure to design parameter estimators for linear and nonlinear regressions, called *dynamic regressor extension and mixing* (DREM) [1] (Figure 1). Via nonlinear manipulation of the data, DREM transforms the problem of estimating a q-dimensional parameter vector into estimating q decoupled, scalar parameters, which ensures the monotonicity of the individual estimation errors.

This technique has been successfully applied in a variety of identification and adaptive control problems, where a significant improvement in the quality of the transients was systematically observed, reducing oscillations and peaks. Practical applications of the DREM procedure include robotics, sensorless control of electrical drives and magnetic levitated systems, and photovoltaic arrays control. In Figure 1(a), a KUKA robot tracks a target moving on a screen. The target's trajectory is approximated as the sum of sinusoidal signals in two dimensions, and the robot estimates online frequencies of these sinusoids to provide adaptive trajectory prediction and accurate tracking. When estimation is performed using

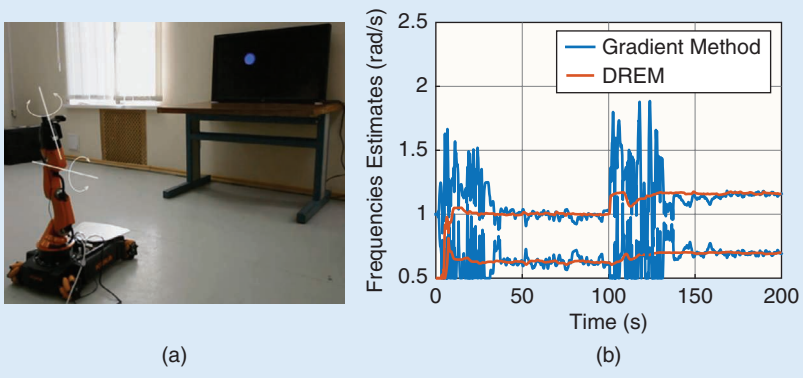

FIGURE 1 The dynamic regressor extension and mixing procedure. (a) The KUKA tracking its target and (b) the estimation of the trajectory parameters. (Courtesy of Stanislav Aranovskiy, Anton Pyrkin, and Alexey Vedyakov.)

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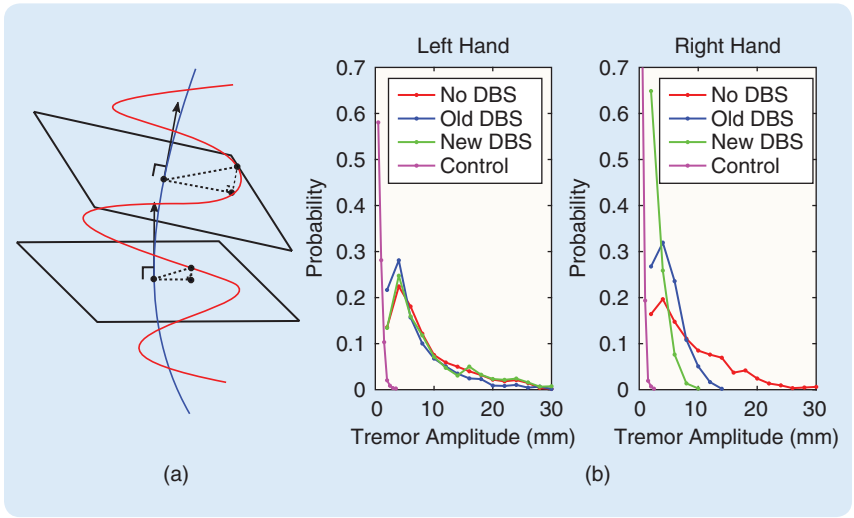

FIGURE 2 An unobtrusive method of quantifying tremors using smartphones. This new tool fuses measurements from the accelerometer, gyroscope, and magnetometer of the native smartphone sensor platform. The (a) tremor signal computation and (b) tremor amplitude distributions. In (a), the tremor signal is computed as the deviation of the hand movement estimated from the smartphone data (red) from the estimated intended voluntary movement (blue). Deep brain stimulation is expected to improve tremors in Parkinson's disease and essential tremors [see (b)]. An estimation of the trajectory parameters is shown in (b). (Courtesy of Alexander Medvedev and Fredrik Olsson.)

standard gradient-based estimators, the transients are poor and tracking performance degrades. The DREM estimator significantly improves the transient behavior and tracking accuracy.

A research team, led by Alexander Medvedev at Information Technology, Uppsala University, Sweden, in collaboration with the Neurology Clinic at the Uppsala University Hospital (UUH), has recently developed an unobtrusive method for quantifying tremors by using smartphones (see Figure 2). In medicine, this method can be applied to a number of neurological conditions, such as Parkinson's disease (PD) or essential tremors (ET), and is intended for use in both on-site and off-site clinics. Measurements of the accelerometer, gyroscope, and magnetometer, from the native smartphone sensor platform, are fused to estimate the actual movement trajectory that arises when the patient handles the phone to answer or place a call. The intended voluntary movement is obtained by filtering the estimated trajectory, and the tremor signal is calculated as the deviation of the latter from the former. Thus, the actual shape of the tremor signal can be studied rather than, for instance, its frequency distribution. Since the tremor signal is nonstationary, the tremor severity is quantified by performing stationary analysis of a Markov chain whose states correspond to different ranges of the tremor amplitude. Note that the tremor amplitude and the frequency are dilapidating for the patient. UUH uses the developed technology to optimize the settings of deep brain stimulation, an advanced chronic treatment for PD and ET that consists of sending electrical impulses to a certain target area in the patient's brain [2].

INVITED SESSIONS, WORKSHOPS, AND CONFERENCES

Since the last TC-SIAC columns in *IEEE Control Systems Magazine*, 19 invited sessions and two workshops have been organized by TC members at the ACC, the CDC, and the IFAC World Congress. These workshops and invited sessions brought together researchers from different theoretical fields (such as system and control theory, machine learning, statistics, and optimization) who focused on important applied topics, such as biomedicine, mechanics, quantum systems, dynamic networks, and various theoretical and applied fields, demonstrating the strong cross-disciplinary nature of the TC.

During the past 18 months, several TC-SIAC members have been deeply involved in the organization of important conferences linked to SIAC. For example, Clara Ionescu was the NOC chair of the Third IFAC Conference on Advances in Proportional-Integral-Derivative Control held in Ghent, Belgium, May 9–11, 2018. This conference gathers academic and industrial experts in the field to present recent research developments in the design of proportional-integral-derivative (PID) controllers and provide a perspective on future requirements for PID controllers in industry, with a focus on Industry 4.0 relevance. There were 164 papers (with 555 authors from 35 countries) presented across nine interactive sessions and 25 oral presentation sessions.

In July 2018, Håkan Hjalmarsson was the general chair of the 18th IFAC Symposium on System Identification in Stockholm, Sweden, July 9–11, 2018. The scope of this symposium covers all aspects of system identification, experimental modeling, signal processing, and adaptive control, ranging from theoretical, methodological, and scientific developments to a large variety of application areas. The International Program Committee received 226 papers and 255 delegates from 37 countries. Highlights included six plenary talks covering reinforcement learning; large-scale statistical learning; power-generating kites; and kernel-based, nonlinear; and dynamic network identification. These impressive figures highlight the numerous activities of TC-SIAC members.

SPECIAL ISSUES

Three special issues were published in 2017:

- "Identification and Control of Nonlinear Electro-Mechanical Systems" in the February 2017 issue of *International Journal of Control*

» "Applied Fractional Calculus in Modeling, Analysis, and Design of Control Systems" in the May 2017 issue of *International Journal of Control*
» "Quantum Control" (dedicated to the occasion of Prof. Ian Petersen's 60th birthday) in the August 2017 issue of *Control Theory and Technology Magazine*.

TC members are working on four new special issues, including "Recent Advances in Control and Verification for Hybrid Systems" in *IET Control Theory and Application*. Approximately 50 papers were reviewed, and, based on their current status, the total number of accepted papers should be 20. The issue "System Identification and Control in Biomedical Applications" is being developed for *IEEE Transactions on Control Systems Technology*, to document and emphasize the role of control systems technology in the challenges of applying feedback control in living organisms, with specific attention to biomedicine. Approximately 50 papers were submitted for this special issue, and, based on their current status, approximately 25 should appear in the issue. Providing state-of-the-art developments about learning from adaptive control (with specific attention to online historical data-driven adaptive control and parameter estimation as well as their applications to various real-world problems) is the main focus of the upcoming special issue "Learning From Adaptive Control Under Relaxed Excitation Conditions" in *International Journal of Adaptive Control and Signal Processing*. Finally, the *International Journal of Robust and Nonlinear Control* special issue "New Trends in Modeling and Control of Hybrid Systems" will include innovative contributions that bring attention to the latest advancements in data-driven modeling, analysis, and control of hybrid dynamic systems. It will highlight the current challenges and open problems in the field as well as new trends to address them. Both special issues are expected to be published in the second half of 2019.

JOIN TC-SIAC

All interested IEEE CSS members are welcome to join TC-SIAC. We are particularly interested in adding fellows with industrial affiliations to the membership. Visit the TC-SIAC website (http://system-identification.ieeecss.org/tc-system-identification/home) for detailed information about members and activities. Then, as an IEEE CSS member, email me (guillaume.mercere@univ-poitiers) to take an active part in TC-SIAC.

Guillaume Mercère

REFERENCES

[1] S. Aranovskiy, A. Bobtsov, R. Ortega, and A. Pyrkin, "Performance enhancement of parameter estimators via dynamic regressor extension and mixing," *IEEE Trans. Autom. Control*, vol. 62, no. 7, pp. 3546–3550, 2017.
[2] F. Olsson and A. Medvedev, "Nonparametric time-domain tremor quantification with smart phone for therapy individualization," *IEEE Trans. Control Syst. Technology*, to be published.

Technical Committee on Automotive Control

Traditionally, when you think of automotive controls, the engine and aftertreatment (emissions) controls, and antilock brakes immediately come to mind. However, with the proliferation of microprocessors and computing power onboard a vehicle, there continues to be improvements in the performance, efficiency, and safety of automotive systems. Take, for example, the advanced driver assistance systems, which can detect and prevent lane departures and even apply the brakes to avoid or mitigate collisions. These features are now standard for many vehicles, thanks in part to research by members of the IEEE Control Systems Society (CSS) Technical Committee on Automotive Controls (TC-AC) over the past decade.

In the next decade, there will likely be a massive shift in the auto industry toward electrification. At the same time, there is a large research effort to expand the capabilities of autonomous driving. These two technologies, seemingly linked only by the timing of their arrival and level of hype, both depend heavily on government policy and incentives and will require changes in social behaviors to be integrated into society. Since TC-AC members have a deep understanding of these transportation systems and integration challenges and their potential and fundamental limitations, they are in a unique position to shepherd them for the advancement of humankind.

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HISTORY AND MISSION

When Luigi Glielmo of the University of Napoli Federico II and Jessy Grizzle of the University of Michigan informally started the committee, it was called the Technical Activity Board on Automotive Control. After its formal approval by the CSS in 1999, the name was changed to TC-AC. Today,