

15th IFAC Workshop on Adaptive and Learning Control Systems

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From July 2 to 4, 2025, 15th IFAC Workshop on Adaptive and Learning Control Systems (ALCOS 2025) took place in Mexico City, Mexico. It was held under the auspices of Technical Committee 1.2 on Adaptive and Learning Systems of the International Federation of Automatic Control (IFAC) and was organized by the Faculty of Electrical Engineering and Electronics of the Autonomous Technological Institute of Mexico (Instituto Tecnológico Autónomo de México, ITAM). The Mexican Association of Automatic Control (Asociación de México de Control Automático, AMCA) was the technical sponsor of the event.

ALCOS is one of IFAC regular workshops, which aim is to exchange ideas and results in the field of adaptive and learning control systems that are used under conditions of parametric and non-parametric uncertainty, nonlinear dynamics, and external disturbances. The event was first held in San Francisco in 1983, and then in Lund, Sweden (1986), Glasgow, Scotland (1989), Grenoble, France (1992), Budapest, Hungary (1995), Glasgow, Scotland (1998), Cernobbio-Como, Italy (2001), Katayama, Japan (2004), St. Petersburg, Russia (2007) [1], Antalya, Turkey (2010), Caen, France (2013) [2], Eindhoven, Netherlands (2016), Southampton, United Kingdom (2019), Casablanca, Morocco (2022).

It should be noted that until 2019 the name of the event was the Adaptation and Learning in Control and Signal Processing (ALCOSP) workshop. Moreover, until 1998, the event was called a symposium (according to IFAC rules, an event is a symposium if the number of participants consistently exceeds 100). However, starting from 1998, the number of participants fell below 100. In 2001, Professor S. Bittanti, who organized ALCOSP in Italy, proposed to broaden its scope and hold the Periodic Control Systems (PSYCO 2001) workshop simultaneously with ALCOSP-2001. This indeed attracted new participants interested in the control of oscillations, including chaotic ones, in mechanics, biology, and other fields, and the total number of participants exceeded 100. Although in subsequent years the number of participants did not reach 100, it was convenient to hold these two events together, and the tradition continued. At the same time, combining two differently focused events at the same time and place sometimes caused confusion, and in early 2017, during an online meeting of Technical Committee 1.2, the issue of changing the event format and name was raised. In fact, there were practically no papers on signal processing at ALCOSP, as signal processing is a part of interest of another technical committee: Committee 1.1 “Identification and Signal Processing.” After a brief discussion in January 2017, it was decided to change the seminar name to the current ALCOS. The field of oscillation control was decided to be implicitly included in the scope of the new workshop.

In its current format, the event was held in Southampton in 2019, in Casablanca in 2022, and in Mexico City in 2025.

Scientists from Russia took an active part in organizing and conducting ALCOS 2025. In particular, A.A. Bobtsov (ITMO University, St. Petersburg) was the co-chair of the conference, and the members of the international program committee were A.L. Fradkov (IPME RAS and SPbU,

St. Petersburg), A.A. Pyrkin (ITMO University, St. Petersburg), A.I. Glushchenko (ICS RAS, Moscow), and six participants from Russia (A.L. Fradkov IPME RAS and SPbU, O.N. Granichin SPbU, A.A. Pyrkin, ITMO University, A.A. Vedyakov, ITMO University, A.A. Peregudin, ITMO University, A.I. Glushchenko, ICS RAS) were chairs or co-chairs of seven sessions.

Of the 53 manuscripts submitted to ALCOS in 2025, the international program committee selected 51 papers that were included in the final workshop program. Twenty-one associate editors and 236 independent reviewers were involved in the review process. Each submitted paper was evaluated by at least two reviewers. The final program included 3 plenary sessions, 1 invited session, and 10 regular sessions. Two parallel sessions were held daily.

About 60 participants from 13 countries (Russia, Mexico, France, India, USA, Brazil, Great Britain, Colombia, China, Morocco, Norway, Canada, Germany) took part in the sessions. The largest number of reports (20) were presented by scientists from Russia. Next in terms of the number of presentations were Mexico (9), India (5), and France (4). Russia was represented by scientists from St. Petersburg, Moscow, Krasnodar and Krasnogorsk.

The relatively small number of presentations is largely due to the particular topic of the workshop scope, in contrast to conferences on control theory in general, such as the European Control Conference (ECC), American Control Conference (ACC), Conference on Decision and Control (CDC), etc. At the same time, such narrow scope makes all sessions being interesting to attend, and only two parallel sections provide the opportunity to attend almost half of all presentations. Looking back over the past 20 years, we note that in 2010, 2016, and 2019, the number of presentations at ALCOS (ALCOSP) also did not exceed 60, in 2007 90 presentations were accepted, and only in 2013 and 2022 this number was above 100 presentations.

The workshop program included three plenary talks.

Professor A.L. Fradkov, representing the Institute for Problems in Mechanical Engineering of Russian Academy of Sciences and Saint Petersburg State University, devoted his presentation to the application of the speed gradient method for modeling, control, adaptation, and learning. He described the current state of the speed gradient method, developed mainly in the 1970s and 1980s, and provided brief information about speed gradient algorithms and their applicability, optimality, and passivity conditions. Applications of the speed gradient method to adaptive control and identification, nonlinear control, network and distributed system control were demonstrated, and examples of the method application in engineering, physical, biological, and environmental systems were provided. Recent modifications and extensions of the method were also mentioned, including non-Euclidean speed gradient algorithms based on Lyapunov–Bregman functions. The concluding part of the report demonstrated the applicability of the speed gradient method to develop models of natural phenomena. The report triggered a lively discussion, during which both classical questions about the connection between the speed gradient method and the second Lyapunov method for the design of adaptive controllers were discussed, as well as important points related to the future development of this method. For example, the possibility of its application to solve control problems in the presence of constraints. Such an extension would be important, in particular, for branches of control theory, in which the task of control design is formulated as an optimization problem.

Professor Joao Hespanha, representing the University of California, Santa Barbara, presented a report on reinforcement learning for large-scale games. The presentation discussed the use of reinforcement learning in zero-sum Markov games for two players with a finite but large state space, the goal of which is to find minimax strategies with “moderate” computations, *i.e.*, the task is to prove the optimality of strategies without exploring the entire state space of the game. An overview was given of the Q-learning method, which was proposed in the late 1980s as an

alternative to the principle of dynamic programming for single-player game and zero-sum games for two players. The approach is based on reinforcement learning and does not require a known Markov model of the system. The report went on to show that most of the studies devoted to proving the correctness of Q-learning are based on establishing that each iteration converges to a single fixed point of a Bellman-type equation, which usually requires exploring the entire state space. The main part of the report demonstrated that for zero-sum games, mathematically correct optimal strategies can be designed using algorithms inspired by Q-learning, without the need for the Q-function to converge across the entire state space. In fact, the samples used to update the Q-function may not even explore the entire set of reachable states, and for certain classes of games, the proportion of explored states becomes smaller and smaller as the size of the state space increases.

Professor Zhong-Ping Jiang from New York University presented a report on the application of learning-based approaches for the design of adaptive optimal controllers. Learning-based control is a direct adaptive control method aimed at adaptation of optimal controllers based on real-time data. The report first demonstrated well-known developments in learning-based control for linear and nonlinear systems with unknown dynamics in continuous time, and then presented the latest results of stability analysis of continuous-time controllers designed on the basis of learning. Considering linear systems, it is possible to use parameterizations in the form of linear regression equations for the synthesis of an adaptive LQ controller, on the basis of which the laws of adaptation of the parameters of such a controller can be obtained, whereas, talking about nonlinear systems, the design of adaptive optimal controllers requires application of universal approximators, in particular — two neural networks in the controller structure (one — to approximate the value of the objective function, the other — to approximate the ideal controller). This leads to the locality of the obtained result in terms of stability, and in the case of disturbances — to the need to assume their smallness. In conclusion, the effectiveness of learning-based control was demonstrated.

The topics of ALCOS 2025 sessions were focused on: adaptive control and identification tasks for linear and nonlinear systems, adaptive observers, network systems control, data-driven control methods, and reinforcement learning. Particular attention was paid to bridge the theoretical developments with applications in such areas as robotics, aerospace, energy systems, and autonomous vehicles. As it was noted at the end of one of the sessions, all presentations were followed by very fruitful discussions, since almost everyone involved in the above-mentioned topics gathered at one place — at ALCOS sessions.

ALCOS 2025 program included only one special session, which was organized by professor O.N. Granicin and E.Yu. Tarasova (Saint Petersburg State University) and was devoted to problem of multi-agent systems control based on the application of the so-called intelligent approaches, including cases of dynamic network topology, noise and external disturbances, etc.

The following should be noted. Recently, not only at ALCOS, but also at ACC, ECC, and CDC, there has been a significant increase in the number of reports on data-driven control and reinforcement learning. Such reports always attract a lot of attention from participants, especially among young scientists. Perhaps this can be explained by the fact that data analysis, machine learning, deep neural networks, and other data processing tools are currently quite popular direction of students teaching. And, for graduates of such specialties, it is the data-driven control and reinforcement learning that seem to be the simplest and most understandable way to enter the control theory. However, everything has its price. For data-driven control, for linear systems, the requirement for a full-rank matrix composed of collected measurements actually means that the parameters of such a system can be estimated, which reduces the solution of

the problem to the application of well-known methods of adaptive and robust control. For reinforcement learning, this price is the strict assumptions to prove the stability, and the locality of the result obtained. This should be kept in mind. This paragraph is debatable, reflects the authors' subjective opinion, and the authors are open to discuss the above by receiving feedback from readers.

We would like to highlight the presentation by professor Miroslav Krstic from the University of California, San Diego, USA. In his report, he proposed an alternative to the well-known sigma modification used in the adaptive laws to ensure: 1) bounded parametric error in the presence of external disturbances and non-parametric uncertainty, 2) convergence of the tracking error, albeit to a bounded set, but with a non-adjustable bound that is proportional to the value of the unknown ideal controller parameters, non-parametric uncertainty, and disturbances. Unlike known solutions, the method described in the report ensures required tracking error in the presence of arbitrary external disturbances and non-parametric uncertainty through the simultaneous application of dead zone, nonlinear damping, and parametric adaptation.

In the opinion of the authors of this note, the workshop venue was extremely well chosen. Mexico City is a very large metropolis with beautiful parks and fascinating architecture. The population of the Mexico City metropolitan area exceeds 21 million people. Thanks to the high-altitude subtropical climate, the air temperature remained moderate throughout the workshop, at around +22°C, which was conducive to calm discussion of scientific topics and communication between scientists. ITAM University, founded in 1946, where all the sessions were held, is a small (about 3500 students) private university in Mexico City, which campus is very well organized and creates a cozy atmosphere. Of course, the seminar participants also had time to visit numerous attractions in Mexico City, such as Teotihuacan, Chapultepec Castle, Constitution Square, National Museum of Anthropology, Palace of Fine Arts, and many others.

We would like to express our gratitude to the workshop organizers, particularly professor Romeo Ortega, Chair of the International Program Committee, and members of the National Organizing Committee, professor Jose Guadalupe Romero, professor Rafael Cisneros, and professor Hugo Rodriguez. Our colleagues not only organized ALCOS 2025 at a very high level, but also held a seminar the day before its start entitled "Commemorating forty years of scientific collaboration between Russia and Mexico in the field of Control Theory," which participants, in addition to the colleagues already mentioned in this note, included professors L.M. Fridman (National Autonomous University of Mexico, UNAM), A.S. Poznyak (Center for Research and Advanced Studies of the National Polytechnic Institute, CINVESTAV-IPN), J. Moreno (National Autonomous University of Mexico, UNAM), I. Chairez (Monterrey Institute of Technology and Higher Education, ITESM), L. Aguilar (Instituto Politecnico Nacional, IPN), J. Davila (Instituto Politecnico Nacional, IPN), V.O. Nikiforov (ITMO University), and others. The presentations made by the seminar attendees focused both on scientific results and familiarizing the audience with the history of Russia-Mexico scientific cooperation in the field of control theory. Such seminars are very valuable for new generations of researchers, as knowledge of history allows them to set meaningful goals and choose scope for further research.

The venue for the next workshop will be chosen in 2026 at IFAC World Congress, which will be held in Busan, South Korea.

More detailed information can be found on the official website <https://alcos2025.itam.mx/>

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