IEEE SMC TC on Fully Actuated System Approach

Fully Actuated System Approach

Fully-actuated system (FAS) approach is a new approach recently discovered for control systems analysis and design.

State-space models were originally proposed to deal with problems directly tied to the states: linear state-space models were firstly proposed by Euler in early 1750 for solving high-order linear differential equations (giving the state responses), and nonlinear ones were used by Lyapunov in 1892 to analyze the limit behavior of the states. Exceptionally, state-space models have been successfully used in the control of linear systems because linear systems are easy to handle. While for control of nonlinear systems, insurmountable difficulties are encountered. As Alberto Isidori put it: "from the mid 1990s, the study of problems of feedback design for MIMO nonlinear systems came to a (almost complete) stall".

In certain practical applications, there exists a type of physical systems which are referred to as FASs. They are often modeled as Lagrangian systems (a type of differential equations of second order), and are widely encountered in the mechanical, electrical, and aerospace fields. They are of the type from which the control vectors can be explicitly solved out, and are therefore inherently more straightforward for controller designs.

However, the set of physical FASs is small. How about the control of the large set of non-FASs? Very recently, the physical FASs are generalized mathematically, and it is shown that, instead of a state-space model, a generalized mathematical FAS model can be obtained for a "controllable" complicated dynamical system. Thus a new methodology termed as FAS approach has been proposed. Instead of converting the model of a dynamical system (including underactuated systems) into a state-space one, the FAS approach converts it into a so-called mathematical FAS model. Then, similar to a physical FAS, the converted mathematical FAS can then be easily controlled and a linear closed-loop system can often be fully or partially obtained with an arbitrarily assignable eigenstructure.

The FAS approach, owing to its distinct advantages, has attracted widespread and rapid-increasing attention ever since its emergence in 2020-2021. By now, over 500 papers on FAS approach have been published by researchers from more than 140 universities and research institutions in more than 20 countries, with nearly a hundred appeared in IEEE Transactions, and over 140 journal papers on practical applications. *Fully actuated system control* has been listed as one of the 12 technical areas in the website of 2026 IFAC World Congress.

Mission of TC

The missions of the proposed TC can be divided into the following three aspects:

1) In scientific research, the proposed TC and its activities will be focused on proposing new results in the field of systems and control based on the FAS approach;
2) In technical development, the proposed TC will support the transfer of discovered "know-how" in the area of system and control theories to potential practical applications;
3) In education, the proposed TC will support young scientists in the field of control systems and applications, and disseminate discovered "know-how" amongst scientific community.

The aim of the proposed TC is to build a community of experts in the area of the FAS approach and control applications, who are excellent scholars in academic organizations and industrial companies. This community will be devoted to the development of more progressive, efficient, and practical methods, with expected impact on multivariable systems control and their applications based on the FAS approach.

Research Scope of TC

As a general methodology parallel to the state-space approach, the FAS approach can be applied to treat various control problems. The scope of the FAS approach is very wide, which includes, but is not limited to, modeling and control of FASs, time-varying and time-delay linear systems, nonholonomic systems, multi-agent systems and hybrid systems, stochastic systems, adaptive and robust control, predictive control, fault diagnosis and fault tolerant control, optimal control and constrained control, process control and micro-grid control, mechatronic systems and robotic control, underwater/ground moving platforms, spacecraft and aircraft control, control of unmanned aerial vehicles, etc.

TC Chairs

Chair: Guang-Ren Duan, *Academician of the Chinese Academy of Sciences, Fellow of IEEE, IFAC, IET, & CAA,* Harbin Institute of Technology, China

Co-Chairs: Guo-Xiang Gu, *Life Fellow of IEEE,* Louisiana State University, USA; Michael V. Basin, *Member of the Mexican Academy of Sciences,* Autonomous University of Nuevo Leon, Mexico; and Levente Kovács, *Rector/President,* Obuda University, Hungary.

TC Activities

The Annual FASTA Conferences The annual conference is fully entitled Conference on Fully Actuated System Theory and Applications (FASTA). FASTA 2022 was held in Harbin, and had over 150 participants; FASTA 2023 was held in Qingdao, and attracted over 430 participants; FASTA 2024 took place in Shenzhen with over 610 participants, and FASTA 2025 was held in Nanjing, with over 1040 participants. FASTA 2026 and FASTA 2027 will be respectively held in Qinhuangdao and Chengdu. Of course, besides the FASTA conferences, this TC will be actively involved with the IEEE SMC conferences.

International Journal of Systems Sciences **Special Issue Series** In 2023, a formal agreement between the TC of FAS Theory and Applications, CAA, and *International Journal of Systems Science* has been made. It is agreed that, since 2023, every year there will a special issue on the FAS approach, entitled *Fully Actuated System Theory and Applications: New Developments in 202#,* published in this journal, with papers mainly selected from that year's FASTA conference. As planned, the special issues in 2023 and 2024 have already appeared. The 2025 issue is now under preparation.

Control Engineering Practice **Special Issue** To further develop the FAS theory and simultaneously extend its applications, a special issue in the IFAC journal *Control Engineering Practice* entitled *Development and Applications of High-order Fully Actuated System Theory* has been proposed. For details, please visit

https://www.editorialmanager.com/conengprac/default.aspx.

Springer Book Series The FAS Approach Book Series entitled *Series of Fully Actuated System Approach for Control and AI* has been proposed with Springer, which is affiliated with the Annual *Conference on Fully Actuated System Theory and Applications* (FASTA).

IEEE FAS Approach TC Meetings The IEEE SMC FAS Approach TC meeting will be held once a year during the FASTA conference to discuss some typical issues. The TC may also organize many other activities such as technical forums and symposiums, industry collaborations and exhibitions, etc.