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Fully Actuated System Approaches: Theory and Applications

WU Ai-Guo · ZHOU Bin · HOU Mingzhe · ZHANG Ying

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Since 1960s, the first-order state space approach has been dominant in analysis and design of control systems. In a state-space model of a dynamical system, the state variable is emphasized. Therefore, some problems relevant to state estimation and the seeking of state solution can be conveniently solved. However, the control variable is the core in the design of controllers. Thus, numerous problems are not yet solved when the first-order state model is applied to nonlinear systems control. In fact, the original models of many practical systems have a second-order fully actuated structure due to the existence of some basic physical laws such as the Newton's law, theorem of linear and angular momentum, Kirchhoff 's laws of current and voltage, etc. In view of the great advantage of full actuation, in 2020 Prof. Guang-Ren Duan made an unprecedented generalization for full actuation from physical to mathematical, proposed the concept of fully-actuated systems (FASs), and drew a big picture for FAS approaches. The FAS model is a control-oriented model, and can provide much convenience for control designs. It can be observed from the recent progress that the FAS approach has been convinced to be powerful tools in dealing with some involved nonlinear control problems. Therefore, it is of important significance to study the FAS approaches and their applications.

For these reasons, the Guest Editors have proposed this Special Issue on "Fully Actuated System Approaches: Theory and Applications", which is aimed at presenting the latest new and significant results on the FAS approaches in every aspect, and their applications in control theory to the readers of the *Journal of Systems Science & Complexity*. The goal is to highlight

WU Ai-Guo
Harbin Institute of Technology (*Shenzhen*), *Shenzhen* 518055, *China; HIT Wuhu Robot Technology Research Institute, Wuhu* 241008, *China.* Email: ag.wu@163.com.
ZHOU Bin · HOU Mingzhe
The Center for Control Theory and Guidance Technology, Harbin Institute of Technology, Harbin 150001, *China.* Email: binzhou@hit.edu.cn; hithyt@hit.edu.cn.
ZHANG Ying
School of Mechanical Engineering and Automation, Harbin Institute of Technology (*Shenzhen*), *Shenzhen* 518055, *China.* Email: zhangyinghit@126.com.

recent advances and developments of the FAS approaches and their applications in control systems analysis and design. This Special Issue has drawn strong interest within the community of applied mathematics, control theory and engineering. Various contributions, focused on the FAS approaches with applications to control theory and other relevant fields, have been submitted for the peer review process.

The Special Issue consists of 18 papers divided into 4 clusters:

1) New trends in FAS approaches.
2) Pole assignment, predictive control and disturbance decoupling of the FAS.
3) Application of the FAS in spacecraft control.
4) Application of the FAS in others.

The first category contains 4 papers. In the paper by Duan[1], both exponential sub-stabilization and Lyapunov global asymptotic stabilization are realized for the well-known Brockett's first example system with the FAS approach as a tool. In the paper by Ning, et al.[2], the global adaptive control problem is addressed for nonlinear systems with time-delays by utilizing the FAS approach. A prescribed error trajectory control method is presented in the paper by Li, et al.[3] for second-order fully actuated systems. In the paper by Shi, et al.[4], a preset-trajectory-based adaptive control law is proposed to stabilize a class of second-order sub-fully actuated systems.

The second category includes 5 papers. In the paper by Zhou and Duan[5], it is pointed out that for a scalar high-order fully actuated (HOFA) linear system, the pole assignment problem is solvable if and only if the desired pole set of the closed-loop system does not include the zero set of the open-loop system if the implementation issue of the controller is taken into account. The FAS approach is adopted in the paper by Gu and Wang[6] to synthesize a class of nonlinear systems. In the papers by Liu[7], and by Wu, et al.[8], the stabilization problems of HOFA nonlinear systems with time-varying and distinct input delays in the discrete-time domain are respectively investigated by means of predictive control schemes. The almost disturbance decoupling problem is explored in the paper by Wang, et al.[9] for HOFA nonlinear systems with strict-feedback form.

The third category contains 4 papers. The FAS approach is adopted by Xiao and Chen[10] to design a control law for attitude tracking of spherical liquid-filled spacecraft. A control scheme is presented by Zhao and Duan[11] for the spacecraft with uncertainties caused by external disturbance, unknown motion information, and inaccurate inertia parameters. In the paper by Duan and Liu[12], the attitude and orbit control is investigated for the combined spacecraft formed after a target spacecraft without the autonomous control ability is captured by a service spacecraft. In the paper by Liu, et al.[13], an optimal controller is designed for spacecraft attitude tracking with the inertial uncertainty and external disturbance by using the FAS approach.

There are 5 papers in the fourth category. A scheme of trajectory tracking control law is proposed in the paper by Kong, et al.[14] for the hovercraft. In the paper by Wu and Liu[15], a quadratic-programming-based integration of the control algorithms is proposed for a class of FASs. A fixed-time leader-follower formation control method is given in the paper by Gao, et

al.[16] for fully-actuated underwater vehicles. In the paper by Zhao, et al.[17], the active control approach of the thermoacoustic instability is investigated in a horizontal Rijke tube. In the paper by Sun, et al.[18], the trajectory tracking control is investigated for a six degree-of-freedom (6-DOF) manipulator based on FAS models.

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