Editorial

Sundarapandian Vaidyanathan*

Research and Development Centre,
Vel Tech University,
Avadi, Chennai-600 062, Tamil Nadu, India
Email: sundarcontrol@gmail.com
Email: sundar@veltechuniv.edu.in
*Corresponding author

Ahmad Taher Azar

College of Computer and Information Sciences,
Prince Sultan University,
Riyadh 11586, Saudi Arabia
Email: aazar@psu.edu.sa
Email: ahmad_t_azar@ieee.org
and
Faculty of Computers and Artificial Intelligence,
Benha University, Egypt
Email: ahmad.azar@fci.bu.edu.eg

Biographical notes: Sundarapandian Vaidyanathan is a Professor and the Dean at the Research and Development Centre, Vel Tech University, Chennai, India. In 1996, he received his DSc in Electrical and Systems Engineering from Washington University, St. Louis, USA. He has published over 560 Scopus indexed research papers and 20 books. His current research focuses on control systems, chaos theory, computational science, circuits and systems modelling. He is in the editorial boards of *IJMIC*, *IJCAT*, *IJAAC*, *IJIEI* and *IJNDC* published by Inderscience Publishers, Olney, UK.

Ahmad Taher Azar is a Research Professor at Prince Sultan University, Riyadh, Kingdom Saudi Arabia, and Associate Director of Research and Initiative Centre. He is also a Professor at the Faculty of Computers and Artificial Intelligence, Benha University, Egypt. He is the Editor-in-Chief of the *International Journal of System Dynamics Applications* (*IJSDA*) and *International Journal of Service Science*, *Management, Engineering, and Technology* (*IJSSMET*), published by IGI Global, USA. He is also the Editor-in-Chief of the *International Journal of Intelligent Engineering Informatics* (*IJIEI*), Inderscience Publishers, Olney, UK. From 2013 to 2017, he was an Associate Editor of *IEEE Transactions on Neural Networks and Learning Systems*; and from 2018 to 2020, he was an Associate Editor of *ISA Transactions*, Elsevier. He is currently an Associate Editor for *IEEE Systems Journal*, Springer's *Human-centric Computing and Information Sciences*, and Elsevier's *Engineering Applications of Artificial Intelligence*. He has expertise in control theory and applications, robotics, process control, artificial intelligence, machine learning and dynamic system modelling. He has authored/co-authored over 350 research papers in prestigious peer-reviewed journals, book chapters, and conference proceedings.

Sliding mode control (SMC) is a nonlinear control method in which the state feedback control law is not a continuous function of time. Instead, the state feedback control law can switch from one continuous structure to another structure based on the current position in the state space. For over 50 years, the SMC has been extensively studied and widely used in many scientific and industrial applications due to its simplicity and robustness against parameter variations and disturbances.

Important types of SMC are classical SMC, integral SMC, second-order SMC and higher order SMC. SMC has applications in several branches of science and engineering like control systems, electrical engineering, mechanical engineering, robotics, network engineering, etc.

This special issue focuses upon recent advances and applications of SMC theory in engineering. It is hoped that this special issue will provide a useful reference for informing recently developed technologies based on SMC theory.

The contents of the selected eight articles are described briefly as follows:

The paper titled 'Fuzzy adaptive finite-time sliding mode controller for trajectory tracking of ship course systems with mismatched uncertainties' by Pooyan Alinaghi Hosseinabadi, Ali Soltani Sharif Abadi and Saad Mekhilef investigates the course control ship systems to achieve trajectory tracking goal precisely in a finite time with all mismatched external disturbances and uncertainties by using proposed fuzzy robust controller. The adaptive method is utilised to estimate the upper bound of the mismatched external disturbances and uncertainties, and their estimation is utilised in the designed control input. The finite-time stability analysis is investigated by utilising only one Lyapunov candidate function for the closed-loop system by utilising combined fuzzy controller, adaptive estimator, and sliding mode controller. The key advantages of the designed control input in this study are robustness against various mismatched disturbances and uncertainties, and ensuring finite-time stability with a fast convergence with smooth tracking motion.

The paper titled 'Non-singular terminal sliding mode control for a class of second-order systems with mismatched uncertainty' by Ning Zhao, Ye Zhang, Xincheng Yang and Dongya Zhao proposes a novel method for a class of second-order systems to solve singularity problem and mismatched uncertainty in terminal sliding mode control (TSMC). Firstly, a state transformation method is designed to eliminate the reaching phase of terminal sliding mode, which can avoid the singularity problem fundamentally. In addition, mismatched uncertainty can be transferred to the same channel with control input after state transformation. Secondly, a novel controller is designed to stabilise the new form of the system in finite-time, while the mismatched uncertainty can be compensated effectively. Numerical simulations further validate the effectiveness of the proposed method.

The paper titled 'Adaptive sliding mode controller design for the bipartite consensus tracking of multi-agent systems with actuator faults and disturbances' by Ehsan Nazemorroaya and Mahnaz Hashemi studies the bipartite consensus problem for second-order nonlinear multi-agent systems in the presence of actuator faults, unknown control gains and unknown external disturbances. The actuator faults are considered as partial loss of effectiveness fault and bias fault. For design controller, the control gains and disturbances only need to have unknown upper bounds. Also, a signed bipartite directed graph is used for describing the communication topology of the multi-agent system. An adaptive sliding mode controller is developed for bipartite consensus tracking of the multi agent system. The proposed adaptive sliding mode controller ensures the

uniformly ultimately bounded cooperative tracking of the multi-agent system. Finally, the correctness and effectiveness of the proposed control method is verified via simulation results.

The paper titled 'A relative analysis of sliding mode control with reaching law for the vector control of a three-phase induction machine' by P. Jisha Kuruvilla and R. Anasraj evaluates the performance dynamics and disturbance rejection property of sliding mode controllers with reaching law method by simulation and experiment in the motor drive. The results obtained are analysed and compared for robust performance to variations in load torque and the chattering issues present. The work concludes with the addition of a proportional factor of sliding variable the reach time is improved whereas if the control gain is multiplied by the sliding function, it reduces the chattering effect. The findings on this study offers good knowledge on each control law and how the performance differentiates for each law. This work also accomplishes a study on the factors that contribute towards the functioning of each control law.

The paper titled 'Modified sliding mode control for a universal active filter-based solar microgrid system' by Buddhadeva Sahoo, Sangram Keshari Routray and Pravat Kumar Rout presents a larger signal model by combining the universal active filter (UAF) and the solar system with a vector switching operation (VSO) in a novel frame. The detailed modelling of the S-UAF using VSO and modified sliding mode control (MSMC) is proposed for achieving better power quality (PQ) operation. MSMC-based novel frame is used to estimate the accurate reference signals for SHAF during dynamic state conditions such as sag/swell, change in irradiance, fault and sensitive load condition. SEAF control is based upon the conventional DQ control strategies and it adjusts the load voltage during dynamic conditions. SHAF is used to balance the grid side current and reduces the harmonic distortion by injecting the appropriate current in quadrature with the load current and facilitates fast transient response during sudden load change by providing better tracking capability and reduction in the switching losses. To validate the proposed controller and S-UAF approach with different test conditions, it is tested in MATLAB/Simulink environment and the related results are discussed.

The paper titled 'A new form of a class of MIMO linear systems for a non-singular terminal sliding mode control' by Ning Zhao, Shouli Gao, Yuankai Song and Dongya Zhao proposes a novel non-singular TSMC method for a class of MIMO linear systems to solve the singularity problem. A state transformation matrix is designed properly to transfer a class of MIMO linear systems into a new form without changing its controllability and observability. Based on it, the traditional non-singular method of second-order nonlinear systems can be used in the new form of MIMO linear systems by adjusting the dimension of coefficients appropriately. The theory analysis is given to lay a foundation to the application of the state transformation method and new SMC algorithm. Then an example is given to validate the effectiveness of the proposed form. Stability analysis and numerical simulations show that the proposed method can guarantee system states to converge to equilibrium point with strong robustness in finite time, and the singularity problem can also be avoided appropriately.

The paper titled 'Fixed-time sliding mode flight control with model-based switching functions of quadrotor unmanned aerial vehicles' by Charles Fallaha, Yassine Kali, Maarouf Saad and Jawhar Ghommam proposes the design of a new sliding mode controller of the attitude fast inner-loop of a drone quadrotor type system. The controller uses the novel model-based switching functions approach, which leads to important

simplifications of the pitch, roll and yaw torques control inputs fed to the quadrotor. The model-based switching functions approach forces as well a complete chattering decoupling of these three torque inputs and enhances the robustness of the closed-loop system. The proposed approach is combined with the fixed-time sliding mode approach, and is experimentally implemented and successfully validated on a quadrotor system.

The paper titled 'Power control of a stand-alone electric generation hybrid system using integral sliding mode controller' by Fatima Ez-zahra Lamzouri, El-Mahjoub Boufounas and Aumeur El Amrani proposes a novel strategy for output power control of an electric generation hybrid system (EGHS), composed of a photovoltaic generation system, a storage battery bank and a variable load. According to different atmospheric conditions and load changes, a robust control based on SMC is designed to satisfy the total power demand in different power system operation modes. Thus, the proposed controller is modified by introducing the integral action in the switching surface, in order to improve transient response with minimum steady state error. Numerical simulations are presented and discussed to demonstrate the performance of the proposed method, using a nonlinear model of the plant. Finally, the simulation results show that the proposed integral sliding mode control (ISMC) strategy ensures better response speed and smaller steady-state error compared to standard SMC.

The guest editors would like to thank all the authors for submitting their manuscripts in this special issue. We would want to acknowledge the reviewers for their contributions in reviewing the papers and providing constructive and useful comments to the authors. Finally, the guest editors would like to specially thank the Editor-in-Chief of *International Journal Automation and Control* (*IJAAC*), Professor Ling Wang (Tsinghua University, China) for his great help and support in organising and coordinating the publication of this special issue.