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Special Issues on "Fractional Order Systems and Controls (FOSC)", guest co-edited by Prof. YangQuan Chen, University of California, Merced, USA; Prof. Dingyü Xue, Northeastern University, China, and Prof. Antonio Visioli, University of Brescia, Italy, have published 54 papers.
Visit http://mechatronics.ucmerced.edu/jas-si-fosc for the original call for papers, two editorials, and the single combined PDF file for all published papers, LaTeX BiBTeX file, and a list of all papers with a hyper-link to each paper and its local PDF.

1. Fudong Ge, YangQuan Chen, Chunhai Kou. Cyber-physical systems as general distributed parameter systems: three types of fractional order models and emerging research opportunities. 2015, 2(4): 353-357
Donghua University, China, University of California, Merced , Utah State University, USA

Cyber-physical system are man-made complex systems coupled with natural processes that, as a whole, should be described by distributed parameter systems in general forms. This paper presents three such general models for generalized DPSs that can be used to characterize complex CPSs. These three different types of fractional operators based DPS models are: fractional Laplacian operator, fractional power of operator or fractional derivative. This research investigation is motivated by many fractional order models describing natural, physical, and anomalous phenomena, such as sub-diffusion process or super-diffusion process. The relationships among these three different operators are explored and explained. Several potential future research opportunities are then articulated followed by some conclusions and remarks.

2. Bruce J. West, Malgorzata Turalska. The Fractional Landau Model. 2016, 3(3), 257-260
Army Research Office, Research Triangle Park, Duke University, USA

Herein the Landau model of the transition from laminar to turbulent fluid flow is generalized to include the effect of memory. The original Landau model is quadratically nonlinear and memoryless, with turbulent fluctuations decaying exponentially. However, recent experiments show a dependence of the decay of fluctuations on memory, with the exponential being replaced by an inverse power law. This transition is explained herein as being due to critical slowing down. The fractional calculus is used to model this memory and to relate the index of the inverse power law decay to that of the fractional derivative in time.

3. Kecai Cao, YangQuan Chen, Daniel Stuart. A Fractional Micro-Macro Model for Crowds of Pedestrians Based on Fractional Mean Field Games. 2016, 3(3), 261-270
Nanjing University of Posts and Telecommunications, China, University of California, Merced , Utah State University, USA

Modeling a crowd of pedestrians has been considered from different aspects. Based on fractional microscopic model that may be much more close to reality, a fractional macroscopic model has been proposed using conservation law of mass. Then in order to characterize the competitive and cooperative interactions among pedestrians, fractional mean field games are utilized in the modeling problem when the number of pedestrians goes to infinity and fractional dynamic model composed of fractional backward and fractional forward equations are constructed in macro scale. Fractional micromacro model for crowds of pedestrians are obtained. Simulation results are also included to illustrate the proposed fractional microscopic model and fractional macroscopic model, respectively.

4. Jiacai Huang, YangQuan Chen, Haibin Li, Xinxin Shi. Fractional Order Modeling of Human Operator Behavior with Second Order Controlled Plant and Experiment Research. 2016, 3(3), 271-280
Nanjing Institute of Technology, China, University of California, Merced , USA

Modeling human operator's dynamics plays a very important role in the manual closed-loop control system, and it is an active research area for several decades. Based on the characteristics of human brain and behavior, a new kind of fractional order mathematical model for human operator in single-input single-output (SISO) systems is proposed. Compared with the traditional models based on the commonly used quasilinear transfer function method or the optimal control theory method, the proposed fractional order model has simpler structure with only few parameters, and each parameter has explicit physical meanings. The actual data and experiment results with the second-order controlled plant illustrate the effectiveness of the proposed method.

5. Yan Ma, Xiuwen Zhou, Bingsi Li, Hong Chen. Fractional Modeling and SOC Estimation of Lithium-ion Battery. 2016, 3(3), 281-287
Jilin University, China

This paper proposes a state of charge (SOC) estimator of Lithium-ion battery based on a fractional order impedance spectra model. Firstly, a battery fractional order impedance model is derived on the grounds of the characteristics of Warburg element and constant phase element over a wide range of frequency domain. Secondly, a frequency fitting method and parameter identification algorithm based on output error are presented to identify parameters of the fractional order model of Lithium-ion battery. Finally, the fractional order Kalman filter approach is introduced to estimate the SOC of the lithium-ion battery based on the fractional order model. The simulation results show that the fractional-order model can ensure an acceptable accuracy of the SOC estimation, and the error of estimation reaches maximally up to 0.5% SOC.

6. Bingsan Chen, Chunyu Li, Benjamin Wilson, Yijian Huang. Fractional Modeling and Analysis of Coupled MR Damping System. 2016, 3(3), 288-294
Fujian University of Technology, China, University of Wisconsin, USA

The coupled magnetorheological damping system addressed in this paper contains rubber spring and magnetorheological damper. The device inherits the damping merits of both the rubber spring and the magnetorheological damper. A fractional-order constitutive equation is introduced to study the viscoelasticity of the combined damper. An introduction to the definitions of fractional calculus and the transfer function representation of a fractional-order system are given. The fractional-order system model of a magnetorheological vibration platform is set up using fractional calculus, and the function of displacement is presented. It is indicated that the fractional-order constitutive equation and the transfer function are feasible and effective means for investigating of magnetorheological vibration device.

7. Xiaojuan Chen, Jun Zhang, Tiedong Ma. Parameter estimation and topology identification of uncertain general fractional-order complex dynamical networks with time delay. 2016, 3(3): 295-303
Chongqing College of Electronic Engineering, Chongqing University, China

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Complex networks have attracted much attention from various fields of sciences and engineering in recent years. However, many complex networks have various uncertain information, such as unknown or uncertain system parameters and topological structure, which greatly affects the system dynamics. Thus, the parameter estimation and structure identification problem has theoretical and practical importance for uncertain complex dynamical networks. This paper investigates identification of unknown system parameters and network topologies in uncertain fractional-order complex network with time delays (including coupling delay and node delay). Based on the stability theorem of fractional-order differential system and the adaptive control technique, a novel and general method is proposed to address this challenge. Finally two representative examples are given to verify the effectiveness of the proposed approach.

8. Cuihong Wang, Huanhuan Li, YangQuan Chen. H∞ Output Feedback Control of Linear Time-invariant Fractional-order Systems over Finite Frequency Range. 2016, 3(3), 304-310
Shanxi Normal University, China, University of California, Merced , USA

This paper focuses on the H∞ output feedback control problem of linear time-invariant fractional-order systems over finite frequency range. Based on the generalized Kalman-Yakubovic-Popov (KYP) Lemma and a key projection lemma, a necessary and sufficient condition is established to ensure the existence of the H∞ output feedback controller over finite frequency range, a desirable property in control engineering practice. By using the matrix congruence transformation, the feedback control gain matrix is decoupled and further parameterized by a scalar matrix. Two iterative linear matrix inequality algorithms are developed to solve this problem. Finally, numerical examples are provided to illustrate the effectiveness of the proposed method.

9. Kai Chen, Junguo Lu, Chuang Li. The Ellipsoidal Invariant Set of Fractional Order Systems Subject to Actuator Saturation: The Convex Combination Form. 2016, 3(3), 311-319
Hainan University, China, Shanghai JiaoTong University, China

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The domain of attraction of a class of fractional order systems subject to saturating actuators is investigated in this paper. We show the domain of attraction is the convex hull of a set of ellipsoids. In this paper, the Lyapunov direct approach and fractional order inequality are applied to estimating the domain of attraction for fractional order systems subject to actuator saturation. We demonstrate that the convex hull of ellipsoids can be made invariant for saturating actuators if each ellipsoid with a bounded control of the saturating actuators is invariant. The estimation on the contractively invariant ellipsoid and construction of the continuous feedback law are derived in terms of linear matrix inequalities (LMIs). Two numerical examples illustrate the effectiveness of the developed method.

10. Mojtaba Naderi Soorki, Mohammad Saleh Tavazoei. Constrained Swarm Stabilization of Fractional Order Linear Time Invariant Swarm Systems. 2016, 3(3), 320-331
Sharif University of Technology, Iran

This paper deals with asymptotic swarm stabilization of fractional order linear time invariant swarm systems in the presence of two constraints: the input saturation constraint and the restriction on distance of the agents from final destination which should be less than a desired value. A feedback control law is proposed for asymptotic swarm stabilization of fractional order swarm systems which guarantees satisfying the above-mentioned constraints. Numerical simulation results are given to confirm the efficiency of the proposed control method.

11. Norelys Aguila-Camacho, Manuel A. Duarte-Mermoud. Improving the Control Energy in Model Reference Adaptive Controllers Using Fractional Adaptive Laws. 2016, 3(3), 332-337
Duarte-Mermoud, University of Chile, Chile

This paper presents the analysis of the control energy consumed in model reference adaptive control schemes using fractional adaptive laws, through simulation studies. The analysis is focused on the energy spent in the control signal represented by means of the integral of the squared control input. Also, the behavior of the integral of the squared control error is included in the analysis. The orders of the adaptive laws were selected by PSO, using an objective function including the ISI and the ISE, with different weighting factors. The results show that, when ISI index is taken into account in the optimization process to determine the orders of adaptive laws, the resulting values are fractional, indicating that control energy of the scheme might be better managed if fractional adaptive laws are used.

12. Arturo Rojas-Moreno. An Approach to Design MIMO FO Controllers for Unstable Nonlinear Plants. 2016, 3(3), 338-344
Universidad de Ingenieria y Tecnologia, Peru

This paper develops an approach to control unstable nonlinear multi-inputs multi-output (MIMO) square plants using MIMO fractional order (FO) controllers. The controller design uses the linear time invariant (LTI) state space representation of the nonlinear model of the plant and the diagonal closedloop transfer matrix (TM) function to ensure decoupling between inputs. Each element of the obtained MIMO controller could be either a transfer function (TF) or a gain. A TF is associated in turn with its corresponding FO TF. For example, a D (Derivative) TF is related to a FO TF of the form D^{δ}, $\delta = [0, 1]$. Two applications were performed to validate the developed approach via experimentation: control of the angular positions of a manipulator, and control of the car and arm positions of a translational manipulator.

13. T. Sathiyaraj, P. Balasubramaniam. Controllability of Fractional Order Stochastic Differential Inclusions with Fractional Brownian Motion in Finite Dimensional Space. 2016, 3(4), 400-410
The Gandhigram Rural Institute-Deemed University, India

Sufficient conditions are formulated for controllability of fractional order stochastic differential inclusions with fractional Brownian motion (fBm) via fixed point theorems, namely the Bohnenblust-Karlin fixed point theorem for the convex case and the Covitz-Nadler fixed point theorem for the nonconvex case. The controllability Grammian matrix is defined by using Mittag-Leffler matrix function. Finally, a numerical example is presented to illustrate the efficiency of the obtained theoretical results.

14. Baris Baykant Alagoz. A Note on Robust Stability Analysis of Fractional Order Interval Systems by Minimum Argument Vertex and Edge Polynomials. 2016, 3(4), 411-421
Inonu University, Turkey

By using power mapping (s=vm), stability analysis of fractional order polynomials was simplified to the stability analysis of expanded degree integer order polynomials in the first Riemann sheet. However, more investigation is needed for revealing properties of power mapping and demonstration of conformity of Hurwitz stability under power mapping of fractional order characteristic polynomials. Contributions of this study have two folds:Firstly, this paper demonstrates conservation of root argument and magnitude relations under power mapping of characteristic polynomials and thus substantiates validity of Hurwitz stability under power mapping of fractional order characteristic polynomials. This also ensures implications of edge theorem for fractional order interval systems. Secondly, in control engineering point of view, numerical robust stability analysis approaches based on the consideration of minimum argument roots of edge and vertex polynomials are presented. For the computer-aided design of fractional order interval control systems, the minimum argument root principle is applied for a finite set of edge and vertex polynomials, which are sampled from parametric uncertainty box. Several illustrative examples are presented to discuss effectiveness of these approaches.

15. Mohammad Saleh Tavazoei. Criteria for Response Monotonicity Preserving in Approximation of Fractional Order Systems. 2016, 3(4), 422-429
Sharif University of Technology, Iran

In approximation of fractional order systems, a significant objective is to preserve the important properties of the original system. The monotonicity of time/frequency responses is one of these properties whose preservation is of great importance in approximation process. Considering this importance, the issues of monotonicity preservation of the step response and monotonicity preservation of the magnitude-frequency response are independently investigated in this paper. In these investigations, some conditions on approximating filters of fractional operators are found to guarantee the preservation of step/magnitude-frequency response monotonicity in approximation process. These conditions are also simplified in some special cases. In addition, numerical simulation results are presented to show the usefulness of the obtained conditions.

16. Hua Chen, Yang Quan Chen. Fractional-order Generalized Principle of Self-support (FOGPSS) in Control System Design. 2016, 3(4), 430-441
Hohai University, China, University of California, Merced, USA

This paper reviews research that studies the principle of self-support in some control systems and proposes a fractional-order generalized PSS framework for the first time. The existing PSS approach focuses on practical tracking problem of integer-order systems including robotic dynamics, high precision linear motor system, multi-axis high precision positioning system with unmeasurable variables, imprecise sensor information, uncertain parameters and external disturbances. More generally, by formulating the fractional PSS concept as a new generalized framework, we will focus on the possible fields of the fractional-order control problems such as practical tracking, -tracking, etc. of robot systems, multiple mobile agents, discrete dynamical systems, time delay systems and other uncertain nonlinear systems. Finally, the practical tracking of a first-order uncertain model of automobile is considered as a simple example to demonstrate the efficiency of the fractional-order generalized principle of self-support control strategy.

17. Songsong Cheng, Shengguo Wang, Yiheng Wei, Qing Liang, Yong Wang. Study on Four Disturbance Observers for FO-LTI Systems. 2016, 3(4), 442-450
University of Science and Technology of China, China, University of North Carolina at Charlotte, USA

This paper addresses the problem of designing disturbance observer for fractional order linear time invariant systems, where the disturbance includes time series expansion disturbance and sinusoidal disturbance. On one hand, the reduced order extended state observer and reduced order cascade extended state observer are proposed for the case that the system state can be measured directly. On the other hand, the extended state observer (ESO) and the cascade extended state observer are presented for another case when the system state cannot be measured directly. It is shown that combination of ROCESO and CESO can achieve a highly effective observation result. In addition, the way how to tune observer parameters to ensure the stability of the observers and reduce the observation error is presented in this paper. Finally, numerical simulations are given to illustrate the effectiveness of the proposed methods.

18. Fabrizio Padula, Antonio Visioli. Set-point Filter Design for a Two-degree-of-freedom Fractional Control System. 2016, 3(4), 451-462
Curtin University, Australia, University of Brescia, Italy

This paper focuses on a new approach to design (possibly fractional) set-point filters for fractional control systems. After designing a smooth and monotonic desired output signal, the necessary command signal is obtained via fractional input-output inversion. Then, a set-point filter is determined based on the synthesized command signal. The filter is computed by minimizing the 2-norm of the difference between the command signal and the filter step response. The proposed methodology allows the designer to synthesize both integer and fractional setpoint filters. The pros and cons of both solutions are discussed in details. This approach is suitable for the design of two degreeof-freedom controllers capable to make the set-point tracking performance almost independent from the feedback part of the controller. Simulation results show the effectiveness of the proposed methodology.

19. Zhuoyun Nie, Qingguo Wang, Ruijuan Liu, Yonghong Lan. Identification and PID Control for a Class of Delay Fractional-order Systems. 2016, 3(4), 463-476
Huaqiao University, Xiamen University of Technology, Xiangtan University, China, University of Johannesburg, South Africa

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In this paper, a new model identification method is developed for a class of delay fractional-order system based on the process step response. Four characteristic functions are defined to characterize the features of the normalized fractionalorder model. Based on the time scaling technology, two identification schemes are proposed for parameters' estimation. The scheme one utilizes three exact points on the step response of the process to calculate model parameters directly. The other scheme employs optimal searching method to adjust the fractional order for the best model identification. The proposed two identification schemes are both applicable to any stable complex process, such as higher-order, under-damped/over-damped, and inimum-phase/nonminimum-phase processes. Furthermore, an optimal PID tuning method is proposed for the delay fractionalorder systems. The requirements on the stability margins and the negative feedback are cast as real part constraints and imaginary part constraints . The constraints are implemented by trigonometric inequalities on the phase variable, and the optimal PID controller is obtained by the minimization of the integral of time absolute error index. Identification and control of a Titanium billet heating process is given for the illustration.

20. Changchun Hua, Tong Zhang, Yafeng Li, Xinping Guan. Robust Output Feedback Control for Fractional Order Nonlinear Systems with Time-varying Delays. 2016, 3(4), 477-482
Yanshan University, Shanghai Jiao Tong University, China

Robust controller design problem is investigated for a class of fractional order nonlinear systems with time varying delays. Firstly, a reduced-order observer is designed. Then, an output feedback controller is designed. Both the designed observer and controller are independent of time delays. By choosing appropriate Lyapunov functions, we prove the designed controller can render the fractional order system asymptotically stable. A simulation example is given to verify the effectiveness of the proposed approach.

21. Yige Zhao, Yuzhen Wang, Haitao Li. State Feedback Control for a Class of Fractional Order Nonlinear Systems. 2016, 3(4), 483-488
University of Jinan, Shandong University, Shandong Normal University, China

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Using the Lyapunov function method, this paper investigates the design of state feedback stabilization controllers for fractional order nonlinear systems in triangular form, and presents a number of new results. First, some new properties of Caputo fractional derivative are presented, and a sufficient condition of asymptotical stability for fractional order nonlinear systems is obtained based on the new properties. Then, by introducing appropriate transformations of coordinates, the problem of controller design is converted into the problem of finding some parameters, which can be certainly obtained by solving the Lyapunov equation and relevant matrix inequalities. Finally, based on the Lyapunov function method, state feedback stabilization controllers making the closed-loop system asymptotically stable are explicitly constructed. A simulation example is given to demonstrate the effectiveness of the proposed design procedure.

22. P. Lino, G. Maione, S. Stasi, F. Padula, A. Visioli, Synthesis of fractional-order PI controllers and fractional-order filters for industrial electrical drives. 2017, 4(1), 58-69
Politecnico di Bari, Italy, Curtin University, Australia

This paper introduces an electrical drives control architecture combining a fractional-order controller and a setpoint pre-filter. The former is based on a fractional-order proportional-integral (PI) unit, with a non-integer order integral action, while the latter can be of integer or non-integer type. To satisfy robustness and dynamic performance specifications, the feedback controller is designed by a loop-shaping technique in the frequency domain. In particular, optimality of the feedback system is pursued to achieve input-output tracking. The setpoint pre-filter is designed by a dynamic inversion technique minimizing the difference between the ideal synthesized command signal (i.e., a smooth monotonic response) and the prefilter step response. Experimental tests validate the methodology and compare the performance of the proposed architecture with well-established control schemes that employ the classical PIbased symmetrical optimum method with a smoothing pre-filter.

23. J. X. Liu, T. B. Zhao, Y. Q. Chen. Maximum power point tracking with fractional order high pass filter for proton exchange membrane fuel cell. 2017, 4(1), 70-79
Xihua University, China, University of California, Merced, USA

Proton exchange membrane fuel cell is widely recognized as a potentially renewable and green energy source based on hydrogen. Maximum power point tracking is one of the most important working conditions to be considered. In order to improve the performance such as convergence and robustness under disturbance and uncertainty, a fractional order high pass filter is applied for the MPPT controller design based on the traditional extremum seeking control. The controller is designed with integerorder integrator and low pass filter together with fractional order high pass filter, by substituting the normal HPF in the original ESC system. With this FOHPF ESC, better convergence and smoother performance are achieved while maintaining the robust specifications. First, tracking stability is discussed under the commensurate-order condition. Then, simulation results are included to validate the proposed new FOHPF ESC scheme under disturbance. Finally, comparison results between FOHPF ESC and the traditional ESC method are also provided.

24. D. Tavares, R. Almeida, and D. F. M. Torres, "Constrained fractional variational problems of variable order," 2017, 4(1), 80-88
Polytechnic Institute of Leiria, University of Aveiro, Portugal

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Isoperimetric problems consist in minimizing or maximizing a cost functional subject to an integral constraint. In this work, we present two fractional isoperimetric problems where the Lagrangian depends on a combined Caputo derivative of variable fractional order and we present a new variational problem subject to a holonomic constraint. We establish necessary optimality conditions in order to determine the minimizers of the fractional problems. The terminal point in the cost integral, as well as the terminal state, are considered to be free, and we obtain corresponding natural boundary conditions.

25. Q. Xue and H. B. Duan, "Robust attitude control for reusable launch vehicles based on fractional calculus and pigeon-inspired optimization," 2017, 4(1), 89-97
Beihang University, China

A robust attitude control system based on fractional order sliding mode control and dynamic inversion approach is presented for the reusable launch vehicle (RLV) during the reentry phase. By introducing the fractional order sliding surface to replace the integer order one, we design robust outer loop controller to compensate the error introduced by inner loop controller designed by dynamic inversion approach. To take the uncertainties of aerodynamic parameters into account, stochastic robustness design approach based on the Monte Carlo simulation and Pigeon-inspired optimization is established to increase the robustness of the controller. Some simulation results are given out which indicate the reliability and effectiveness of the attitude control system.

26. V. S. Krishnasamy, S. Mashayekhi, and M. Razzaghi, "Numerical solutions of fractional differential equations by using fractional Taylor basis," 2017, 4(1), 98-106
Mississippi State University, Florida State University, USA

A new numerical method for solving fractional differential equations (FDEs) is presented. The method is based upon the fractional Taylor basis approximations. The operational matrix of the fractional integration for the fractional Taylor basis is introduced. This matrix is then utilized to reduce the solution of the fractional differential equations to a system of algebraic equations. Illustrative examples are included to demonstrate the validity and applicability of this technique.

27. W. J. Gu, Y. G. Yu, and W. Hu, "Artificial bee colony algorithmbased parameter estimation of fractional-order chaotic system with time delay," 2017, 4(1), 107-113
Beijing Jiaotong University, China

It is an important issue to estimate parameters of fractional-order chaotic systems in nonlinear science, which has received increasing interest in recent years. In this paper, time delay and fractional order as well as system's parameters are concerned by treating the time delay and fractional order as additional parameters. The parameter estimation is converted into a multi-dimensional optimization problem. A new scheme based on artificial bee colony algorithm is proposed to solve the optimization problem. Numerical experiments are performed on two typical time-delay fractional-order chaotic systems to verify the effectiveness of the proposed method.

28. S. Das and V. K. Yadav, "Stability analysis, chaos control of fractional order Vallis and El-Nino systems and their synchronization," 2017, 4(1), 114-124
Banaras Hindu University, India

The authors have studied the stability analysis and chaos control of the fractional order Vallis and El-Nino systems. The chaos control of these systems is studied using nonlinear control method with the help of a new lemma for Caputo derivative and Lyapunov stability theory. The synchronization between the systems for different fractional order cases and numerical simulation through graphical plots for different particular cases clearly exhibit that the method is

easy to implement and reliable for synchronization of fractional order chaotic systems. The comparison of time of synchronization when the systems pair approaches from standard order to fractional order is the key feature of the article.

29. A. Bekir, O. Guner, and A. Cevikel, "The exp-function method for some time-fractional differential equations," 2017, 4(2), 315-321
Eskisehir Osmangazi University, Cankiri Karatekin University, Yildiz Technical University, Turkey

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The fractional derivatives in the sense of modified Riemann-Liouville derivative and the Exp-function method are employed for constructing the exact solutions of nonlinear time fractional partial differential equations in mathematical physics. As a result, some new exact solutions for them are successfully established. It is indicated that the solutions obtained by the Exp-function method are reliable, straightforward and effective method for strongly nonlinear fractional partial equations with modified Riemann-Liouville derivative by Jumarie's. This approach can also be applied to other nonlinear time and space fractional differential equations.

30. Y. Zhao, Y. Li, F. Y. Zhou, Z. K. Zhou, and Y. Q. Chen, "An iterative learning approach to identify fractional order KiBaM model," 2017, 4(2), 322-331
Shandong University, China, University of California, Merced, USA

This paper discusses the parameter and differentiation order identification of continuous fractional order KiBaM models in ARX and OE forms. The least squares method is applied to the identification of nonlinear and linear parameters, in which the Grünwald-Letnikov definition and short memory principle are applied to compute the fractional order derivatives. An adaptive P-type order learning law is proposed to estimate the differentiation order iteratively and accurately. Particularly, a unique estimation result and a fast convergence speed can be arrived by using the small gain strategy, which is unidirectional and has certain advantages than some state-of-art methods. The proposed strategy can be successfully applied to the nonlinear systems with quasi-linear characteristics. The numerical simulations are shown to validate the concepts.

31. W. Y. Ma, Y. J. Wu, and C. P. Li, "Pinning synchronization between two general fractional complex dynamical networks with external disturbances," 2017, 4(2), 332-339
Lanzhou University, Northwest University for Nationalities, Shanghai University, China

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The pinning synchronization between two fractional complex dynamical networks with nonlinear coupling, time delays and external disturbances is investigated. A Lyapunov-like theorem for the fractional system with time delays is obtained. A class of novel controllers is designed for the pinning synchronization of fractional complex networks with disturbances. By using this technique, fractional calculus theory and linear matrix inequalities, all nodes of the fractional complex networks reach complete synchronization. In the above framework, the coupling-configuration matrix and the innercoupling matrix are not necessarily symmetric. All involved numerical simulations verify the effectiveness of the proposed scheme.

32. M. J. Lazo, D. F. M. Torres, "Variational calculus with conformable fractional derivatives," 2017, 4(2), 340-352
Estatística e Física-FURG, Brazil, University of Aveiro, Portugal

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Invariant conditions for conformable fractional problems of the calculus of variations under the presence of external forces in the dynamics are studied. Depending on the type of transformations considered, different necessary conditions of invariance are obtained. As particular cases, we prove fractional versions of Noether's symmetry theorem. Invariant conditions for fractional optimal control problems, using the Hamiltonian formalism, are also investigated. As an example of potential application in Physics, we show that with conformable derivatives it is possible to formulate an Action Principle for particles under frictional forces that is far simpler than the one obtained with classical fractional derivatives.

33. J. H. Wang, L. Y. Qiao, Y. Q. Ye, and Y. Q. Chen, "Fractional envelope analysis for rolling element bearing weak fault feature extraction," 2017, 4(2), 353-360
Nantong University, Nanjing University of Aeronautics and Astronautics, China, University of California, Merced, USA

The bearing weak fault feature extraction is crucial to mechanical fault diagnosis and machine condition monitoring. Envelope analysis based on Hilbert transform has been widely used in bearing fault feature extraction. A generalization of the Hilbert transform, the fractional Hilbert transform is defined in the frequency domain, it is based upon the modification of spatial filter with a fractional parameter, and it can be used to construct a new kind of fractional analytic signal. By performing spectrum analysis on the fractional envelope signal, the fractional envelope spectrum can be obtained. When weak faults occur in a bearing, some of the characteristic frequencies will clearly appear in the fractional envelope spectrum. These characteristic frequencies can be used for bearing weak fault feature extraction. The effectiveness of the proposed method is verified through simulation signal and experiment data.

34. M. Xiao, G. P. Jiang, J. D. Cao, and W. X. Zheng, "Local bifurcation analysis of a delayed fractional-order dynamic model of dual congestion control algorithms", 2017, 4(2), 361-369
Nanjing University of Posts and Telecommunications, Southeast University, China, Western Sydney University, Australia

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We propose a delayed fractional-order congestion control model which is more accurate than the original integer-order model when depicting the dual congestion control algorithms. The presence of fractional orders requires the use of suitable criteria which usually make the analytical work so harder. Based on the stability theorems on delayed fractionalorder differential equations, we study the issue of the stability and bifurcations for such a model by choosing the communication delay as the bifurcation parameter. By analyzing the associated characteristic equation, some explicit conditions for the local stability of the equilibrium are given for the delayed fractionalorder model of congestion control algorithms. Moreover, the Hopf bifurcation conditions for general delayed fractional-order systems are proposed. The existence of Hopf bifurcations at the equilibrium is established. The critical values of the delay are identified, where the Hopf bifurcations occur and a family of oscillations bifurcate from the equilibrium. Same as the delay, the fractional order normally plays an important role in the dynamics of delayed fractional-order systems. It is found that the critical value of Hopf bifurcations is crucially dependent on the fractional order. Finally, numerical simulations are carried out to illustrate the main results.

35. Y. Yang, and D. Y. Xue, "Modified grey model predictor design using optimal fractional-order accumulation calculus," DOI: 10.1109/JAS.2017.7510355
Northeastern University, China

The major advantage of grey system theory is that both incomplete information and unclear problems can be processed precisely. Considering that the modeling of grey model depends on the preprocessing of the original data, the fractional-order accumulation calculus could be used to do preprocessing. In this paper, the residual sequence represented by Fourier series is used to ameliorate performance of the fractionalorder accumulation GM(1, 1) and improve the accuracy of predictor. The state space model of optimally modified GM(1, 1) predictor is given and genetic algorithm is used to find the smallest relative error during the modeling step. Furthermore, the fractional form of continuous GM(1, 1) is given to enlarge the content of prediction model. The simulation results illustrated that the fractional-order calculus could be used to depict the GM precisely with more degrees of freedom. Meanwhile, the ranges of the parameters and model application could be enlarged with better performance. The method of modified GM predictor using optimal fractional-order accumulation calculus is expected to be widely used in data processing, model theory, prediction control and related fields.

36. J. B. Long, H. B. Wang, P. Li and H. S. Fan, "Applications of Fractional Lower Order Time-Frequency Representation to Machine Bearing Fault Diagnosis", 10.1109/JAS.2016.7510190
Jiujiang university, China

The machinery fault signal is a typical non-Gaussian and non-stationary process. The fault signal can be described by SaS distribution model because of the presence of impulses. Time-frequency distribution is a useful tool to extract helpful information of the machinery fault signal. Various fractional lower order time-frequency distribution methods have been proposed based on fractional lower order statistics, which include fractional lower order short time Fourier transform, fractional lower order Wigner-Ville distributions , fractional lower order Cohen class time-frequency distributions, fractional lower order adaptive kernel time-frequency distributions and adaptive fractional lower order time-frequency auto-regressive moving average model time-frequency representation method. The methods and the exiting methods based on second order statistics in SaS distribution environments are compared, simulation results show that the new methods have better performances than the existing methods. The advantages and disadvantages of the improved time-frequency methods have been summarized. Last, the new methods are applied to analyze the outer race fault signals, the results illustrate their good performances.

37. J. M. Wei, Y. A. Hu, and M. M. Sun, "An exploration on adaptive iterative learning control for a class of commensurate high-order uncertain nonlinear fractional order systems," DOI: 10.1109/JAS.2017.7510361
Naval Aeronautical Engineering Institute, China

This paper explores the adaptive iterative learning control method in the control of fraction order systems for the first time. An adaptive iterative learning control scheme is presented for a class of commensurate high-order uncertain nonlinear fractional order systems in the presence of disturbance. To facilitate the controller design, a sliding mode surface of tracking errors is designed by using sufficient conditions of linear fraction order. To relax the assumption of the identical initial condition in iterative learning control, a new boundary layer function is proposed by employing Mittag- Leffler function. The uncertainty in the system is compensated for by utilizing radial basis function neural network. Fractional order differential type updating laws and difference type learning law are designed to estimate unknown constant parameters and time-varying parameter, respecitvely. The hyperbolic tangent function and a convergent series sequence are used to design robust control term for neural network approximation error and bounded disturbance, simultaneously guaranteeing the learning convergence along iteration. The system output is proved to converge to a small neighborhood of the desired trajectory by constructing Lyapnov-like composite energy function containing new integral type Lyapunov function, while keeping all the closed-loop signals bounded. Finally, a simulation example is presented to verify the effectiveness of the proposed approach.

38. Amit S. Chopade, Swapnil W. Khubalkar, A. S. Junghare, M. V. Aware, and Shantanu Das, " Design and Implementation of Digital Fractional Order PID Controller using Optimal Pole-Zero Approximation Method for Magnetic Levitation System", DOI: 10.1109/JAS.2016.7510181
Visvesvaraya National Institute of Technology, Bhabha Atomic Research Centre, India

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The aim of this paper is to employ fractional order proportional integral derivative controller and integer order PID controller to control the position of the levitated object in a magnetic levitation system, which is inherently nonlinear and unstable system. The proposal is to deploy discrete optimal pole-zero approximation method for realization of digital fractional order controller. An approach of phase shaping by slope cancellation of asymptotic phase plots for zeros and poles within given bandwidth is explored. The controller parameters are tuned using dynamic particle swarm optimization technique. Effectiveness of the proposed control scheme is verified by simulation and experimental results. The performance of realized digital FO-PID controller has been compared with that of the integer order PID controllers. It is observed that effort required in fractional order control is smaller as compared with its integer counterpart for obtaining the same system performance.

39. Manjeet Kumar, Apoorva Aggarwal, Tarun Rawat and Harish Parthasarathy, "Optimal Nonlinear System Identification Using Fractional Delay Second-Order Volterra System", DOI: 10.1109/JAS.2016.751018
Netaji Subhas Institute of Technology, India

The aim of this work is to design a fractional delay second order Volterra filter that takes a discrete time sequence as input and its output is as close as possible to the output of a given nonlinear unknown system which may have higher degree nonlinearities in the least square sense. The basic reason for such a design is that rather than including higher than second degree nonlinearities in the designed system, we use the fractional delay degrees of freedom to approximate the given system. The advantage is in terms of obtaining a better approximation of the given nonlinear system than is possible by using only integer delays (since we are giving more degrees of freedom via the fractional delays) and simultaneously it does not require to incorporate higher degree nonlinearities than two. This work hinges around the fact that if the input signal is a decimated version of another signal by a factor of M, then fractional delays can be regarded as delays by integers less than M. Using the well-known formula for calculating the DTFT of a decimated signal, we then arrive at an expression for the DTFT of the output of a fractional delay system in terms of the unknown first and second order Volterra system coefficients and the fractional delays. The final energy function to be minimized is the norm square of the difference between the DTFT of the given output and the DTFT of the output of the fractional delay system. Minimization over the filter coefficients is a linear problem and thus the final problem is to minimize a highly nonlinear function of the fractional delays which is accomplished using search techniques like the gradient-search and nature inspired optimization algorithms. The effectiveness of the proposed method is demonstrated using two nonlinear benchmark systems tested with five different input signals. The accuracy of the stated models using the globally convergent metaheuristic, cuckoo-search algorithm are observed to be superior when compared with other techniques such as real-coded genetic algorithm, PSO and GS methods. Finally, statistical analysis affirms the potential of the proposed designs for its successful implementation.

40. S. Y. Shao and M. Chen. "Fractional-Order Control for a Novel Chaotic System without Equilibrium", DOI: 10.1109/JAS.2016.7510124
Nanjing University of Aeronautics and Astronautics, China

The control problem is discussed for a chaotic system without equilibrium in this paper. On the basis of the linear mathematical model of the two-wheeled self-balancing robot, a novel chaotic system which has no equilibrium is proposed. The basic dynamical properties of this new system are studied via Lyapunov exponents and Poincar´e map. To further demonstrate the physical realizability of the presented novel chaotic system, a chaotic circuit is designed. By using fractional-order operators, a controller is designed based on the state-feedback method. According to the Gronwall inequality, Laplace transform and Mittag-Leffler function, a new control scheme is explored for the whole closed-loop system. Under the developed control scheme, the state variables of the closed-loop system are controlled to stabilize them to zero. Finally, the numerical simulation results of the chaotic system with equilibrium and without equilibrium illustrate the effectiveness of the proposed control scheme.

41. Khatir Khettab, Samir Ladaci, and Yassine Bensafia, "Fuzzy Adaptive Control of a Fractional Order Chaotic System with Unknown Control Gain

Sign Using a Fractional Order Nussbaum Gain", DOI: 10.1109/JAS.2016.7510169
University of Mohamed Boudiaf, University of Skikda, Mentouri University, Algeria

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In this paper we propose an improved fuzzy adaptive control strategy, for a class of nonlinear chaotic fractional order (SISO) systems with unknown control gain sign. The online control algorithm uses fuzzy logic sets for the identification of the fractional order chaotic system, whereas the lack of a priori knowledge on the control directions is solved by introducing a fractional order Nussbaum gain. Based on Lyapunov stability theorem, stability analysis is performed for the proposed control method for an acceptable synchronization error level. In this work, the Gr¨unwald-Letnikov method is used for numerical approximation of the fractional order systems. A simulation example is given to illustrate the effectiveness of the proposed control scheme.

42. Sen Li, Rongxi He, Bin Lin, Fei Sun, "DOA Estimation Based on Sparse Representation of the Fractional Lower Order Statistics in Impulsive Noise", DOI: 10.1109/JAS.2016.7510187
Dalian Maritime University, China

This paper is mainly to deal with the problem of DOA estimations of multiple narrow-band sources impinging on a uniform linear array under impulsive noise environments. By modeling the impulsive noise as –stable distribution, new methods which combine the sparse signal representation technique and fractional lower order statistics theory are proposed. In the new algorithms, the fractional lower order statistics vectors of the array output signal are sparsely represented on an overcomplete basis and the DOAs can be effectively estimated by searching the sparsest coefficients. To enhance the robustness performance of the proposed algorithms, the improved algorithms are advanced by eliminating the fractional lower order statistics of the noise from the fractional lower order statistics vector of the array output through a linear transformation. Simulation results are shown to demonstrate the effectiveness of the proposed methods for a wide range of highly impulsive environments.

43. Xuefeng Zhang, "Relationship Between Integer Order Systems and Fractional Order Systems and Its Two Applications", DOI: 10.1109/JAS.2016.7510205
Northeastern University, China

Existence of periodic solutions and stability of fractional order dynamic systems are two important and difficult issues in fractional order systems (FOS) field. In this paper, the relationship between integer order systems (IOS) and fractional order systems is discussed. A new proof method based on the above involved relationship for the non existence of periodic solutions of rational fractional order linear time invariant systems is derived. Rational fractional order linear time invariant autonomous system is proved to be equivalent to an integer order linear time invariant non-autonomous system. It is further proved that stability of a fractional order linear time invariant autonomous system is equivalent to the stability of another corresponding integer order linear time invariant autonomous system. The examples and state figures are given to illustrate the effects of conclusion derived.

44. Shaobo He, Kehui Sun, and Huihai Wang, "Dynamics of the Fractional-order Lorenz System Based on Adomian Decomposition Method and Its DSP Implementation", 10.1109/JAS.2016.7510133
Central South University, China

Dynamics and digital circuit implementation of the fractional-order Lorenz system are investigated by employing Adomian decomposition method (ADM). Dynamics of the fractional-order Lorenz system with derivative order and parameter varying is analyzed by means of Lyapunov exponents, bifurcation diagram, chaos diagram and phase diagram. Results show that the fractional-order Lorenz system has rich dynamical behavior and it is a potential model for application. It is also found that the minimum order is affected by numerical algorithm and time step size. Finally, the fractional-order system is implemented on DSP digital circuit. Phase diagrams generated by the DSP are consistent with that generated by simulation.

45. Lilian Huang, Longlong Wang, and Donghai Shi, "Discrete Fractional Order Chaotic Systems Synchronization Based on the Variable Structure Control with a New Discrete Reaching-law", DOI: 10.1109/JAS.2016. 7510016
Harbin Engineering University, China

We directly derive a new discrete state space expression of the fractional order chaotic system based on the fractional order Grnwald-Letnikow definition and design a variable structure controller with a new faster reachinglaw. The new reaching-law has the advantages of weakening the high frequency shake. Firstly, the condition of the discrete sliding mode surface is demonstrated. Then a multi-parametric function for sliding mode surface is constructed for weakening the high frequency shake through improving the Gao discrete reachinglaw. Finally, the newly designed variable structure controller is applied to realize the synchronization of two different order discrete fractional chaotic systems. The simulation results show that the designed controller in this paper is effective, as it can achieve the synchronization of the discrete fractional order chaotic systems with external disturbances. Theoretical analysis and simulation results prove the effectiveness and robustness of this control method.

46. Hossein Aminikhah, Mahdieh Tahmasebi, and Mahmoud Mohammadi Roozbahani, "The Multi-scale Method for Solving Nonlinear Time Space Fractional Partial Differential Equations", DOI: 10.1109/JAS.2016.7510058
University of Guilan, Iran

We present a new algorithm to solve a kind of nonlinear time space-fractional partial differential equations on a finite domain. The method is based on B-spline wavelets approximations, some of these functions are reshaped to satisfy on boundary conditions exactly. The Adams fractional method is used to reduce the problem to a system of equations. By multiscale method this system is divided into some smaller systems which have less computations. We get an approximated solution which is more accurate on some subdomains by combining the solutions of these systems. Illustrative examples are included to demonstrate the validity and applicability of our proposed technique, also the stability of the method is discussed.

47. Quan Xu, Shengxian Zhuang, Yingfeng Zeng, and Jian Xiao, "Decentralized Adaptive Strategies for Synchronization of Fractional-Order Complex Networks", 10.1109/JAS.2016. 7510142
Southwest Jiaotong University, China

This paper focuses on synchronization of fractionalorder complex dynamical networks with decentralized adaptive coupling. Based on local information among neighboring nodes, two fractional-order decentralized adaptive strategies are designed to tune all or only a small fraction of the coupling gains respectively. By constructing quadratic Lyapunov functions and utilizing fractional inequality techniques, Mittag-Leffler function, and Laplace transform, two sufficient conditions are derived for reaching network synchronization by using the proposed adaptive laws. Finally, two numerical examples are given to verify the theoretical results.

48. Hadi Delavari and Milad Mohadeszadeh, "Robust Finite-time Synchronization of Non-Identical Fractional-order Hyperchaotic Systems and its Application in Secure Communication", DOI: 10.1109/JAS.2016. 7510145
Hamedan University of Technology, Iran

This paper proposes a novel adaptive sliding mode control method for synchronization of non-identical fractional-order chaotic and hyper-chaotic systems. Under the existence of system uncertainties and external disturbances, finite-time synchronization between two FO chaotic and hyperchaotic systems is achieved by introducing a novel adaptive sliding mode controller. Here in this paper, a fractional sliding surface is proposed. A stability criterion for FO nonlinear dynamic systems is introduced. Sufficient conditions to guarantee stable synchronization are given in the sense of the Lyapunov stability theorem. To tackle the uncertainties and external disturbances, appropriate adaptation laws are introduced. PSO is used for estimating the controller parameters. Finally, finite-time synchronization of the FO chaotic and hyper-chaotic systems is applied to secure communication.

49. Najeeb Alam Khan, Tooba Hameed, "An Implementation of Haar Wavelet Based Method for Numerical Treatment of Time-fractional Schrodinger and Coupled Schrodinger Systems", DOI: 10.1109/JAS.2016. 7510193
University of Karachi, Pakistan

The objective of this paper is to solve the timefractional Schrodinger and coupled Schrodinger differential equations with appropriate initial conditions by using the Haar wavelet approximation. For the most part, this endeavor is made to enlarge the pertinence of the Haar wavelet method to solve a coupled system of time-fractional partial differential equations. As a general rule, piecewise constant approximation of a function at different resolutions is presentational characteristic of Haar wavelet method through which it converts the differential equation into the Sylvester equation that can be further simplifiedeasily. Study of the TFSE is theoretical and experimental research and it also helps in the development of automation science, physics, and engineering as well. Illustratively, several test problems are discussed to draw an effective conclusion, supported by the graphical and tabulated results of included examples, to reveal the proficiency and adaptability of the method.

50. Ameya Anil Kesarkar, and N. Selvaganesan, "Asymptotic Magnitude Bode Plots of Fractional-Order Transfer Functions", DOI: 10.1109/ JAS.2016.7510196
Indian Space Research Organization, India

Development of asymptotic magnitude Bode plots for integer-order transfer functions is a well-established topic in the control theory. However, construction of such plots for the fractional-order transfer functions has not received much attention in the existing literature. In the present paper, we investigate in this direction and derive the procedures for sketching asymptotic magnitude Bode plots for some of the popular fractional-order controllers . In addition, we deduce these plots for general fractional commensurate-order transfer functions as well. As applications of this work, we illustrate the analysis of the designed fractional-control loop and the identification of fractional-order transfer function from a given plot.

51. Ruoxun Zhang, Shiping Yang, Shiwen Feng, "Stability analysis of a class of nonlinear fractional differential systems with Riemann-Liouville derivative", 10.1109/ JAS.2016.7510199
Xingtai University, China

This paper investigates the stability of n-dimensional nonlinear fractional differential systems with Riemann-Liouville derivative. By using the Mittag-Leffler function, Laplace transform and the Gronwall-Bellman lemma, one sufficient condition is attained for the asymptotical stability of a class of nonlinear fractional differential systems whose order lies in $(0, 2)$. According to this theory, if the nonlinear term satisfies some conditions, then the stability condition for nonlinear fractional differential systems is the same as the ones for corresponding linear systems. Several examples are provided to illustrate the applications of our result.

52. Shanshan Li, Chunna Zhao, Yong Guan, Zhiping Shi, Xiaojuan Li, Rui Wang, and Qianying Zhang, "Research on the Higher-order Logic Formalization of Fractance Element", DOI: 10.1109/ JAS.2016.7510208
Capital Normal University, China

Fractance element reflects the fractional order behavior of circuits, which can show the characteristics of the actual circuits. Higher-order logic theorem proving is based on the rigorous and correct mathematical theories. It becomes more and more important in the verifications of high-reliability systems. Fractance element is formalized using the proof of higher-order logic theorem in this paper. Firstly, the formalized model of fractional calculus which is based on Caputo definition is established in higher-order logic theorem proof tool. Then some properties of fractional calculus are proved, including the zero order property, the fractional differential of a constant and the consistency of fractional calculus and integer order calculus. Finally, fractance element and fractional differential circuit constituted by fractance element are formally analyzed. These formalizations demonstrate the effectiveness of the formal method in the analysis of fractance element.

53. Hongyong Yang, Fuyong Wang and Fujun Han, "Containment Control of Fractional Order Multi-Agent Systems with Time Delays", 10.1109/ JAS.2016. 7510211
Ludong University, China

In complex environments, many distributed multiagent systems are described with the fractional-order dynamics. In this paper, containment control of fractional-order multiagent systems with multiple leader agents are studied. Firstly, the collaborative control of fractional-order multi-agent systems with multiple leaders is analyzed in a directed network without delays. Then, by using Laplace transform and frequency domain theorem, containment consensus of networked FOMAS with time delays is investigated in an undirected network, and a critical value of delays is obtained to ensure the containment consensus of FOMAS. Finally, numerical simulations are shown to verify the results.

54. Lifeng Wu, Sifeng Liu , and Yingjie Yang, "Using Fractional Order Method to Generalize Strengthening Buffer Operator and Weakening Buffer Operator", 10.1109/ JAS.2016. 7510214
Hebei University of Engineering, China, De Montfort University, UK

To reveal the relationship between the weakening buffer operator and strengthening buffer operator, the traditional integer order buffer operator is extended to fractional order one. Fractional order buffer operator not only can generalize the weakening buffer operator and the strengthening buffer operator, but also realize tiny adjustment of buffer effect. The effectiveness of grey model (GM(1,1)) with the fractional order buffer operator is validated by six cases.