New advances in Instrument Detection and Control

1. Introduction

Recent developments in computation and network technologies have contributed much to the successful handling of complex problems in biology, physics, engineering, mining, economics, etc. It is worth mentioning that the recent technological advances have further enhanced the integration of the real-time cyber and the physical world, which would lead to more reliable, productive, and efficient industries and businesses. Generally, these complex system problems tend to share a number of interesting properties from the theoretical analysis and design viewpoint. The key features of such systems are that the nonlinear interactions among its components can lead to interesting emergent behaviour and incomplete measurements affect the overall system performance.

The main aim of this special issue is to bring together the latest/innovative knowledge and developments for handling complex systems in instrument, detection and control domains. Topics include, but are not limited to: (1) control systems theory; (2) networked control and estimation; and (3) system reliability and safety. The solicited submissions to this special issue are from the researchers in engineering and mathematics. After a rigorous peer-review process, 19 papers have been selected that provide solutions, or early promises, to modelling, analysis, measure, detection, control and estimation problems of real-world complex systems, such as time-delay systems, nonlinear systems, power systems, economic systems, electromechanical systems, the gas–liquid two-phase flow, the gas turbine, and so on.

2. The special issue papers

2.1. On control systems theory

The stability analysis and control design have been the important topics in both communities of dynamical system and control engineering. In recent years, some new results have been proposed for time-delay systems, nonlinear systems, finance systems and anti-angiogenic systems, etc.

In the paper entitled ‘Stability Analysis for Delayed Neural Networks based on a Generalized Free-weighting Matrix Integral Inequality’ by Z. Zhao et al., by using more information of time delay, a new augmented Lyapunov–Krasovskii functional is constructed. A generalized free-weighting matrix integral inequality is chosen to estimate the derivative of single integral terms more accurately. Meanwhile, the Jensen integral inequality and the improved convex combination are combined to estimate integral terms with an activation function. As a result, a novel stability criterion with less conservatism is established.

In the work entitled ‘Estimating the Boundary of the Region of Attraction of Lotka–Volterra System with Time Delays’ by J. Yang et al., the local stability problem and estimates of the region of attraction (RA) is considered for the Lotka–Volterra (L–V) competitive system with time-delays. Based on the quadratic system theory, the appropriate Lyapunov–Krasovskii functional and the less conservative integral inequalities, a local stability condition is obtained and the estimate of the RA is discussed. Furthermore, the corresponding optimization problem about the estimate of the RA is proposed.

In the paper entitled ‘Asymptotic Dynamics of an Anti-angiogenic System in Tumour Growth’ by X. Yu and Q. Zhang, the Neumann initial-boundary problem is studied for the anti-angiogenic system in tumour growth. The known results show that the problem possesses a unique global-in-time bounded classical solution for some sufficiently smooth initial data. For the large time behaviour of the global solution, by establishing some estimates based on semigroup theory, the authors prove that the solution approaches the homogeneous steady state as the time tends to infinity.

In the work entitled ‘Further Results on Delay-Dependent Robust $H_\infty$ Control for Uncertain Systems with Interval Time-Varying Delays’ by H. Liu et al., the robust $H_\infty$ control problem is considered for uncertain linear systems with interval time-varying delays. The key features of the proposed method are the employment of a tighter integral inequality and the construction of an appropriate Lyapunov–Krasovskii functional. Using the proposed method, delay-dependent conditions with less conservatism are first derived. Then, the robust $H_\infty$ controller design and performance analysis are discussed.

In the work entitled ‘$H_\infty$ Control for a Hyperchaotic Finance System with External Disturbance based on the
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Quadratic System Theory’ by E. Xu et al., using the quadratic system theory, an augmented Lyapunov functional, some integral inequalities and rigorous mathematical derivations, a sufficient condition is first established for a hyperchaotic system under the delayed feedback controller in terms of linear matrix inequalities under which the closed-loop system can achieve some desirable performances including the boundedness, the $H_{\infty}$ performance and the asymptotic stability. Moreover, several convex optimization problems are formulated to obtain the optimal performance indices.

2.2. On networked control and estimation

Over the past several decades, the networked control and estimation problems have gained significant attention in control and signal processing communities due to its clear engineering background in the hot-rolled strip, the gas turbine, and the gas-liquid two-phase flow, etc. In recent years, many important techniques and algorithms have been proposed for the networked control and the state estimation.

In the work entitled ‘Reduced-order Observer-based Interval Estimation for Discrete-time Linear Systems’ by Y. Chen et al., the discrete-time linear system is transformed into a reduced-order system via a special equivalent transformation, which depends on the orthogonal procedure on the output matrix. Then, a kind of robust reduced-order observer is developed such that the states of the original discrete-time system can be indirectly estimated, where the $H_{\infty}$ technique is used to attenuate the effects of disturbances. Based on the estimated states provided by the reduced-order observer, the interval estimation can be obtained by reachability analysis.

In the hot rolling process, the mechanical properties of steel materials are important to steel quality. The bendability is one of the key parameters to evaluate the formability of the strip. In the paper entitled ‘Causes Detection of Unqualified Bendability of Hot Rolled Strip via Improved RankBoost with Multiple Feature Ranking Algorithms’ by F. He et al., a model to find the causes of bendability of hot-rolled strip is built based on an improved RankBoost with multiple feature selection algorithms using historical data. Firstly, the related process variables and bendability results are collected. And then, seven feature ranking methods are used to rank the significance of features individually. Finally, to summarize the results of the seven methods, the total importance of every feature can be obtained using the improved RankBoost method to select the most important features as the major causes.

The two-phase flow system widely exists in industrial production processes such as petroleum, chemical industry, nuclear power and metallurgy. It has been identified that the two-phase flow system often exhibits the complex non-linear characteristics. In the work entitled ‘Feature Extraction and Identification of Gas-liquid Two-phase Flow based on Fractal Theory’ by C. Fan et al., based on the fractal theory, the authors characterize the fractal characteristics of the two-phase flow system. The experimental results show that the proposed method can effectively identify signals of different flow patterns, especially the transitional flow pattern, and reflect the complexity of gas–liquid two phases.

The existing short-term load forecast methods for power systems will lead to the low accuracy or even failure of the load prediction method since the multi-stage load change and weather fluctuation factors are not considered. In the paper entitled ‘Electric Short-term Load Forecast Integrated Method based on Time-segment and Improved MDSC-BP’ by R. Wang et al., based on multi-resources data, an integrated forecast method is proposed for the electric short-term load forecast, which improves the maximum deviation similarity criterion of time-segment BP neural network. Finally, a load forecast of a certain area shows that the prediction accuracy of different types of days can reach more than 96%.

In the past couple of decades, the problem of direction of arrival (DOA) estimation for narrowband sources has been studied extensively because of its wide application in many fields such as radar, navigation and wireless communication. In the paper entitled ‘A New Model for DOA Estimation and Its Solution by Multi-target Intermittent Particle Swarm Optimization’ by L. Cui et al., a new method based on the Vector Error Model (VEM) is proposed for estimating the DOAs, which do not need the source number in advance. The algorithm of multi-target intermittent particle swarm optimization (MIPSO) was adopted to solve the VEM, and the performance of the VEM-MIPSO method was analyzed through simulations for a uniform linear array and an L-shaped array respectively.

2.3. On system reliability and safety

Recently, more and more attention has been paid to the reliability and safety of complex systems (such as the gas turbine, the electromechanical system, the electric vehicle alarm system, etc).

The fault detection and diagnosis of a gas turbine are of great significance for guaranteeing the complicated dynamic systems working normally and safely. Most of the existing fault diagnosis methods, based on convolutional neural networks, have certain limitations in extracting correlations of multi-channel data features. In the work entitled ‘Fault Diagnosis of Gas Turbine based on
Matrix Capsules with EM Routing’ by Y. Zhao et al., based on matrix capsules with EM routing, a fault diagnosis approach is proposed for a gas turbine. First of all, three channels data, which respectively represent acceleration, pressure and pulse, are integrated into one image to feed into the network. Secondly, network models based on the matrix capsules start to be trained by using the input dataset which contains fault image and normal image. Finally, the pre-trained capsules model is used to diagnose the state of testing data.

In the paper entitled ‘A Hierarchical Fuzzy Comprehensive Evaluation Algorithm for Running States of an Electromechanical System’ by F. Wang et al., a fuzzy hierarchical comprehensive evaluation algorithm including fuzzy matrix and comprehensive evaluation matrix calculation is proposed to accurately evaluate the running state of an electromechanical system. The analytic hierarchy process is included in the algorithm, which calculates the state of each subsystem from top to bottom and the states are used as the evaluation factor of the upper system. The idea of degradation degrees is introduced to standardize the indicators. The experimental results show that the established state evaluation model can accurately judge the operation state of the system with not too much data.

Aiming at the problem of most electric vehicles (EV) sounding false alarms due to touches, in the work entitled ‘Electric Vehicle Regional Management System based on the BSP Model and Multi-Information Fusion’ by Z. Zeng et al., an EV alarm regionalization management control system is designed based on multi-information fusion and the BSP model. The proposed system uses multiple sensors to detect the state of the EV, and realizes multi-sensor information fusion by the Lagrange interpolation method. The ZigBee networking technology is used to carry out the regional management of EV alarms, establish a BSP model, realize the synchronous transmission of system status detection signals, and finally complete the alarm function. The experimental results show that the false alarm rate of the proposed alarm system that performs the multi-information fusion is greatly reduced.

2.4. On other fields

In recent years, many improved algorithms have been proposed for the video fingerprinting, the object detection, the image dehazing and software vulnerability mining, etc. Such algorithms play a vital important role in identification, detection, and control of complex systems.

In order to reduce the computer memory and accelerate retrieval, video fingerprinting has gradually developed into an important part of video copy detection. In the paper entitled ‘Compact Video Fingerprinting via an Improved Capsule Net’ by L. Wei et al., an end-to-end fingerprinting via a capsule net is proposed. In order to capture video features, a capsule net, based on a 3D/2D mixed convolution module, is designed, which maps raw data to compact real vector directly. A new designed adaptive margin triplet loss function is introduced, and it can automatically adjust the loss according to the sample distance. In the work entitled ‘Video Fingerprinting based on Quadruplet Convolutional Neural Network’ by X. Li et al., the authors propose a compact video fingerprinting based on a quadruplet convolutional neural network. The algorithm consists of four branch networks with shared weights, each branch network contains feature extraction and quantization coding. The experimental results performed on the public dataset show that the algorithm can effectively improve the robustness and distinctiveness.

In the work entitled ‘An Improved YOLOv3 Model based on Skipping Connections and Spatial Pyramid Pooling’ by X. Zhang et al., an improved YOLOv3 model with skipping connections is proposed for the object detection. Firstly, a dataset is created by a web crawler and annotated it, and then the dataset is clustered to optimize the anchor parameters. Due to the DenseNet structure and the SPPNet structure are introduced, deep features fused with shallow features and network accuracy are improved. Finally, the multi-objective loss function combined with mean square error loss and cross-entropy loss is used to regress and correct the prediction frame, so the accuracy of network detection is improved.

In the work entitled ‘Single Image Dehazing Algorithm based on Pyramid Multi-Scale Transposed Convolutional Network’ by K. Wang et al., the authors design a real end-to-end image dehazing network to directly learn the mapping relationship between hazy images and the corresponding clear images. In this network, the cascaded feature extraction blocks extract the diversified feature information of the input images by multi-channel concatenation structure. In order to reconstruct high-quality dehazed images relieving the colour distortion, a multi-scale transposed convolution block is designed to gradually expand the resolution of the obtained feature maps, and the skip connections from the feature extraction module are introduced to supplement the detailed information of the feature map pyramid.

Voxel grid is widely used in point cloud segmentation due to its regularity. However, the memory consumption caused by high resolution restricts the performance of voxel grid. In the work entitled ‘An Improved Volumetric Grid Deep Network Model for Point Cloud Segmentation’ by X. Zhang et al., an improved voxel grid deep network model is proposed to represent more comprehensive point cloud features at the same resolution. Firstly, the point cloud data are structured within a voxel bounding
box to correspond with the three-dimensional convolution kernel, and a fixed number of point coordinates are selected to generate the point feature vector. Then, in order to consider the distribution characteristics, the reliability coefficient is used as an equivalent descriptor of the point cloud distribution density. Finally, a corresponding deep network is constructed to deal with the above features.

Fuzzy testing is the most effective method for vulnerability mining, which can deal with complex programmes better than other vulnerability mining techniques and has strong scalability. However, in the large-scale vulnerability analysis test, the fuzzy test input sample set faces the challenges of low quality, high repeatability and low availability etc. In the work entitled "Research on Reducing Fuzzy Test Sample Set based on Heuristic Genetic Algorithm" by Z. Wang et al., the heuristic genetic algorithm is proposed. By using 0–1 matrix, the genetic algorithm is improved with a consideration of practical problems and the execution path for sample set is selected and compressed through approximation algorithm, thus obtaining a smallest sample set and accelerating the efficiency of fuzzy test.

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Appendix: Published papers in the order they appear in the editorial

Papers on Topic of control systems theory

(1) Stability analysis for delayed neural networks based on a generalized free-weighting matrix integral inequality, Zhizheng Zhao, Wei Qian & Xiaozhuo Xu (Contact), Published Online, DOI: 10.1080/21642583.2020.1858363.

(2) Estimating the boundary of the region of attraction of Lotka–Volterra system with time delays, Juanjuan Yang (Contact), Rui Dong & Juntao Wang, Published Online, DOI: 10.1080/21642583.2020.1846003.

(3) Asymptotic dynamics of an anti-angiogenic system in tumour growth, Xue Yu & Qingshan Zhang (Contact), Published Online, DOI: 10.1080/21642583.2020.1865215.

(4) Further results on delay-dependent robust $H_{\infty}$ control for uncertain systems with interval time-varying delays, Haibo Liu (Contact), Wei Qian, Weimei Xing & Zhizheng Zhao, Published Online, DOI: 10.1080/21642583.2020.1833785.

(5) $H_{\infty}$ control for a hyperchaotic finance system with external disturbance based on the quadratic system theory, Erfeng Xu (Contact), Kunbao Ma & Yonggang Chen, Published Online, DOI: 10.1080/21642583.2020.1848658.

Papers on Topic of networked control and estimation

(1) Reduced-order observer-based interval estimation for discrete-time linear systems, Yantao Chen, Junqi Yang (Contact), Zhenhua Wang & Hongwei Zhang, Published Online, DOI: 10.1080/21642583.2020.1843085.

(2) Causes detection of unqualified bendability of hot rolled strip via improved RankBoost with multiple feature ranking algorithms, Fei He (Contact), Lidong Wang & Honglei Wang, Published Online, DOI: 10.1080/21642583.2020.1843084.

(3) Feature extraction and identification of gas–liquid two-phase flow based on fractal theory, Chunling Fan (Contact), Zhongcheng Li, Qihua Fan, Jiangan Qin & Miaomiao Liu, Published Online, DOI: 10.1080/21642583.2020.1843561.

(4) Electric short-term load forecast integrated method based on time-segment and improved MDSC-BP, Rui Wang, Shiwen Chen & Jing Lu (Contact), Published Online, DOI: 10.1080/21642583.2020.1843088.

(5) A new model for DOA estimation and its solution by multi-target intermittent particle swarm optimization, Lizhi Cui, Peichao Zhao (Contact), Xinwei Li, et al., Published Online, DOI: 10.1080/21642583.2020.1836525.

Papers on Topic of system reliability and safety

(1) Fault diagnosis of gas turbine based on matrix capsules with EM routing, Yunji Zhao (Contact), Menglin Zhou, Nannan Zhang, Xiaohuox Xu & Xinliang Zhang, Published Online, DOI: 10.1080/21642583.2020.1833783.

(2) A hierarchical fuzzy comprehensive evaluation algorithm for running states of an Electromechanical system, Fuzhong Wang, Sumin Han (Contact), Yuanyuan Li & Meng Zhou, Published Online, DOI: 10.1080/21642583.2020.1843086.

(3) Electric vehicle regional management system based on the BSP model and multi-information fusion, Zhihui Zeng (Contact) & Xintong Sun, Published Online, DOI: 10.1080/21642583.2020.1822947.

Papers on Topic of other fields

(1) Compact video fingerprinting via an improved capsule net, Li Xinwei (Contact), Xu Lianghao & Yang Yi, Published Online, DOI: 10.1080/21642583.2020.1833782.

(2) Video fingerprinting based on quadruplet convolutional neural network, Xinwei Li, Chen Guo, Yi Yang (Contact) & Lianghao Xu, Online, DOI: 10.1080/21642583.2020.1822946.

(3) An improved YOLOv3 model based on skipping connections and spatial pyramid pooling, Xinliang Zhang (Contact), Wanru Wang, Yunji Zhao & Heng Xie, Published Online, DOI: 10.1080/21642583.2020.1824132.

(4) Single image dehazing algorithm based on pyramid multi-scale transposed convolutional network, Keping Wang, Yumeng Duan (Contact) & Yi Yang, Published Online, DOI: 10.1080/21642583.2020.1843780.

(5) An improved volumetric grid deep network model for point cloud segmentation, Xinliang Zhang (Contact), Chenlin Fu, Zhizheng Zhao, Wei Qian & Xiaozhuo Xu (Contact), Published Online, DOI: 10.1080/21642583.2020.1848658.
(6) Research on reducing fuzzy test sample set based on heuristic genetic algorithm, Zhihua Wang (Contact), Manman Cheng & Yongjian Wang, Published Online, DOI: 10.1080/21642583.2020.1843087.

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