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GUEST EDITORIAL
On general systems with randomly occurring incomplete information

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1. Systems with randomly occurring incomplete information

In the system and control community, the incomplete information is generally regarded as the results of (1) our limited knowledge in modelling real-world systems; and (2) the physical constraints on the devices for collecting, transmitting, storing and processing information. In terms of system modelling, the incomplete information typically includes the parameter uncertainties and norm-bounded nonlinearities that occur with certain bounds. As for the physical constraints, two well-known examples are the actuator/sensor saturation caused by the limited power/altitude of the devices as well as the signal quantization caused by limited bandwidth for signal propagation.

Traditionally, the incomplete information is assumed to occur in a deterministic way, that is, it always happens in a certain environment. Such an assumption is, however, not always true. Recently, in response to the development of network technologies, the incomplete information often appears in a random fashion dependent on the random fluctuation of the network loads/conditions whose probabilistic distribution could be estimated a priori through statistical tests. Two intensively studied examples are the packet dropouts and communication delays. So far, the phenomenon of randomly occurring incomplete information (ROII) has become more and more prevalent in networked environments, and a great deal of research attention has devoted to the investigation on the ROII including randomly varying nonlinearities, randomly occurring mixed time-delays, randomly occurring parameter uncertainties, randomly occurring quantization errors, to name just a few. ROII, if not properly handled, would seriously deteriorate the performance of a control system. It is, therefore, the purpose of this special issue to examine (1) how ROII impacts on the system behaviour and (2) how to analyse/control systems with ROII.

2. The special issue

The analysis and control problems for general systems with ROII have already become vitally important for control engineers, mathematicians, and computer scientists to manage, analyze, interpret and synthesize functional information from real-world networked systems. This special issue aims to bring together the latest approaches to understanding, estimating and controlling systems with ROII in a quantitative way. Topics include, but are not limited to, the system modelling, parameter identification, state estimation and systems control with various ROII where the incomplete information includes nonlinearities, uncertainties, time-delays, saturations, quantization, failures, channel fading, deception attacks, etc.

We have solicited submissions to this special issue from computer scientists, electrical engineers, control engineers, and mathematicians. After a rigorous peer review process, 13 papers have been selected that provide novel advanced and nontraditional methods, solutions, or early promises, to manage, analyze, and interpret dynamical behaviours of complex systems with ROII. These papers have covered both the theoretical and practical aspects of the system modelling, parameter identification, state estimation, synchronization, and systems control with various ROII.

3. The papers

In the networked world nowadays, the signals are commonly transmitted through networks which may undergo the inevitable network-induced phenomena. This special issue starts with a solution to the distributed estimation problem over sensor networks with network-induced phenomena described by random measurement matrices. To be specific, in the paper entitled "*Distributed Estimation based on Covariances under Network-induced Phenomena Described by Random Measurement Matrices*" by R. Caballero-Águila et al., the recursive distributed filtering and fixed-point smoothing algorithms are given based on the measurements through sensor networks perturbed by random parameter matrices and additive noises. The estimation problem is addressed under the assumption that the evolution model of the signal is unknown and only information about its mean and covariance functions is required. Moreover, the proposed observation model provides a unified framework to cover some network-induced random phenomena such as missing measurements or sensor gain degradation. By employing the innovation approach, the intermediate distributed optimal least-squares linear estimators are firstly obtained at each sensor node, processing the available output measurements, not only from the own sensor but also from its neighboring sensors according to the network topology. Subsequently, the distributed estimators are designed at each node as the least-squares matrix-weighted linear combination of the intermediate estimators within its neighborhood. It is worth mentioning that the developed algorithms use the covariance information only and there is no need to require the state-space model of the signal. The recursive expressions for the estimation error covariance matrices are also derived in order to compare the accuracy of the estimators. Finally, a simulation example is given to illustrate the effectiveness of the proposed estimation algorithms.

The traditional control framework is established based on an ideal assumption that the measurement signals are sampled and transmitted without loss of data. However, in many engineering systems especially in a networked environment, the perfect communication is not always possible probably due to the limited bandwidths and/or network congestion. It should be noted that the partial signal may be lost at certain time points. Hence, the control problem with incomplete information has begun to receive the initial research attention. In the paper entitled "*A New Framework for Output Feedback Controller Design for a Class of Discrete-time Stochastic Nonlinear System with Quantization and Missing Measurement*" by D. Liu et al., the problems of analysis and synthesis are investigated for a class of discrete time-delay nonlinear systems with quantization and missing measurements. It is assumed that the system measurement is quantized by using a logarithmic quantizer before it is transmitted, and the measurement data would be missing described by a Bernoulli distributed white sequence. In addition, the nonlinearities are assumed to satisfy the sector conditions. Sufficient conditions are given to determine the existence of the desired controllers and the explicit form of the controller parameters is proposed. A numerical example is provided to show the usefulness of the proposed control scheme. Subsequently, in the paper "*Robust Fuzzy Control for Stochastic Markovian Jumping Systems via Sliding Mode Method*" by B. Chen et al., the problem of sliding mode control (SMC) is studied for Itô nonlinear Markovian jumping systems. In the controlled fuzzy systems, each local system is not required to share the same input channel. By means of some specified matrices, the sliding surface corresponding to every mode is designed and the connections among sliding surfaces under Markovian jumping are also established. Furthermore, the SMC law involving the transition rates is synthesized to guarantee the reachability of the sliding mode dynamics for each mode when the sliding surface changes from one to another under Markovian switching. It is shown that both the reachability of the sliding surfaces and the stability of the sliding mode dynamics can be ensured. Finally, a numerical example is given to demonstrate the usefulness of the developed control method.

In practical situations, sensor networks have obtained an ongoing attention due primarily to the attractive application insight in distributed control of robotics, environmental monitoring, information collection, and so on. There exists an important problem in sensor networks, that is, how to design a series of distributed estimators/filters to extract the state information from observations contaminated with external disturbances. On the other hand, in comparison with conventional time-triggered communication, event-triggered communication mechanism allows a considerable reduction of the network resource occupancy while maintaining the guaranteed filtering performance, avoids some injurious transmission phenomena such as data packet dropouts and transmission delays, and extends the lifetime of the services. Therefore, the consideration of the event-triggered communication mechanism is very important in sensor networks due to its strong capability of decreasing the unnecessary executions of the systems and saving energy. In the paper entitled "*Event-based Distributed Set-membership Filtering for a Class of Time-varying Nonlinear Systems over Sensor Networks with Saturation Effects*" by G. Wei et al., the distributed set-membership filtering problem is discussed for a class of time-varying nonlinear systems over sensor networks with saturation effects. Both sensor saturations and event-triggered mechanism are considered in a simultaneous framework. Different from the traditional periodic sample-data approach, the measurement information to the filter side is updated only when the pre-defined event-triggered condition is satisfied. For each node, the proposed novel event-triggered mechanism can reduce the unnecessary information transmission between sensors and filters. A set of distributed set-membership filters is constructed such that, for all the admissible unknown but bounded noises, nonlinearities and sensor saturations, the set of all possible states can be determined. The desired filter parameters are obtained by solving a recursive linear matrix inequality that can be computed recursively by using the standard numerical software. Finally, a numerical example is provided to illustrate the effectiveness of proposed set-membership filtering method.

State estimation has long been a research topic of fundamental importance in signal processing, communications and control applications. As the ever-increasing popularity of networks, more and more signal process algorithms are executed over communication networks due to the advantage of decreasing the hardwiring, the installation cost and implementation difficulties. However, the communication capacity limitations and unreliable network characteristics may yield missing measurements and randomly occurring deception attacks induced by artificial actions. In the paper entitled "*Recursive State Estimation for Discrete Time-varying Stochastic Nonlinear Systems with Randomly Occurring Deception Attacks*" by D. Ding et al., the state estimation problem is discussed for a class of discrete time-varying stochastic nonlinear systems with randomly occurring deception attacks. The stochastic nonlinearity described by statistical means is addressed, which can cover several classes of well-studied nonlinearities as special cases. The randomly occurring deception attacks are modelled by a random variable obeying the Bernoulli distribution. A state estimator is designed and the recursion of the upper bound for estimation error covariance is obtained at each sampling instant. Such an upper bound is minimized by properly designing the estimator gain and the proposed estimation scheme is of a recursive form suitable for the online computation. Subsequently, in the paper entitled "*Unknown Input and State Estimation for Linear Discrete-time Systems with Missing Measurements and Correlated Noises*" by H. Shu et al., the simultaneous input and state estimation problem is investigated for a class of linear discrete-time systems with missing measurements and correlated noises. The missing measurements occur in a random way and are governed by a series of mutually independent random variables obeying a Bernoulli distribution. The process and measurement noises under consideration are correlated at same time step. A necessary and sufficient condition is first given to guarantee that the input and state estimators are unbiased. Next, the design of the gain matrices is transformed into an optimization problem with constraint conditions and the desired gain matrices are designed by minimizing the estimation error covariance matrices. The design algorithm is concluded by using the established analysis results. Finally, a numerical example is given to show the effectiveness of the proposed estimation algorithm.

The problem of the optimal state estimation and parameter identification for stochastic Gaussian systems with unknown parameters has been systematically treated. However, the number of algorithms concerning on the mean-square filtering for systems with white Poisson noises is relatively small. In the paper entitled "*Mean-square State and Parameter Estimation for Stochastic Linear Systems with Gaussian and Poisson Noises*" by M. Basin et al., the design problems of the mean-square filter and parameter estimator are addressed for linear stochastic systems with unknown parameters over linear observations, where unknown parameters are considered combinations of Gaussian and Poisson processes. The filtering problem is formalized considering the unknown parameters as additional system states satisfying linear stochastic differential equations. Hence, the problem is reduced to the filtering problem for polynomial (bilinear) states subject to both Gaussian and Poisson white noises over linear observations. The resulting mean-square filter serves as an identifier for the unknown parameters. Finally, a simulation example is provided to show the effectiveness of the proposed mean-square filter and parameter estimator. Subsequently, in the paper entitled "*Gaussian Estimation for Discretely Observed Cox-Ingersoll-Ross Model*" by C. Wei et al., the parameter estimation problem is studied for Cox-Ingersoll-Ross model based on discrete observation. Firstly, a new discretized process is established based on the Euler-Maruyama scheme and the density function of this new process is given. Then, the parameter estimators are obtained by employing the maximum likelihood method. Subsequently, the explicit expressions of the estimation error for the parameters in drift item are given and the strong consistency of the estimators are shown by employing the law of large numbers for martingale. Moreover, the consistency properties of all parameter estimators are proved by applying the law of large numbers for martingales, the Holder's inequality, Burkholder-Davis-Gundy inequality, Cauchy-Schwarz inequality and martingale moment inequality. Finally, a numerical example for estimators and the absolute error between estimators and true values is given to demonstrate the effectiveness of the proposed estimation approach.

Synchronization has long been one of the most fundamental problems in the complex networks and there has been a great number of results available in the existing literature. It should be pointed out that most of the results concerning on the synchronization problem assume that the coupling strengths among nodes are deterministic. However, it is not always true in the practical complex networks and the coupling strengths may exhibit some uncertainties especially in the networked environment. So far, the uncertain coupling is largely overlooked mainly because of the mathematical complexity. On the other hand, both the time delays and nonlinearities might be subject to abrupt changes and hence exhibit stochasticity in realistic systems. Such a situation is referred to as the randomly occurring phenomenon, which means that some network behavior occurs in a probabilistic way and changes in terms of certain types. In the paper entitled "*Robust Synchronization of Complex Networks with Uncertain Couplings and Incomplete Information*" by F. Wang et al., the mean square exponential synchronization problem is studied for complex networks with simultaneous presence of uncertain time-varying stochastic couplings and randomly occurring incomplete information. The addressed randomly occurring incomplete information includes both the randomly occurring delay and the randomly occurring nonlinearities, which are modeled by two mutually Bernoulli distributed white sequences with known probabilities. By using the coordinate transformation, the addressed complex network can be exponentially synchronized in the mean square if the mean square exponential stability of a transformed subsystem can be assured. By employing the Lyapunov functional method, an easy-to-verify sufficient criterion is established. It is shown that the proposed sufficient criterion characterizes the joint impacts of the system parameters of the single agent, the structure of the network and the statistical quantities of the uncertainties on the synchronization of the complex networks. Finally, two numerical examples are given to illustrate the effectiveness of the proposed methods.

The fault diagnosis and isolation and fault-tolerant control problems have attracted much attention owing to the increasing security and reliability demand of modern control systems. However, in practice, it is generally difficult to obtain the accurate information of the size and shape of the fault from an fault diagnosis and isolation scheme only. It is fortunate that fault estimation technique is capable of providing the better information of the size of the fault, thereby helps reconstruct the fault signals occurred in the practical systems. In the paper entitled "*On Co-design of Filter and Fault Estimator Against Randomly Occurring Nonlinearities and Randomly Occurring Deception Attacks*" by J. Hu et al., the co-design problem of filter and fault estimator is investigated for a class of time-varying nonlinear stochastic systems with randomly occurring nonlinearities and randomly occurring deception attacks. Two mutually independent random variables obeying the Bernoulli distribution are employed to characterize the phenomena of the randomly occurring nonlinearities and randomly occurring deception attacks. The co-design problem of the robust filter and fault estimator is firstly converted into the recursive filter design problem by using the augmentation approach. A new filtering scheme is designed, for both randomly occurring nonlinearities and randomly occurring deception attacks, an upper bound of the filtering error covariance is obtained and such an upper bound is minimized by properly designing the filter gain at each sampling instant. In particular, the impact from both randomly occurring nonlinearities and randomly occurring deception attacks onto the filtering performance is examined. The explicit form of the filter gain is given by solving the Riccati-like difference equations. Subsequently, in the paper "*Distributed Fault Estimation with Randomly Occurring Uncertainties over Sensor Networks*" by H. Dong et al., the distributed fault estimation problem is investigated for a class of uncertain stochastic systems over sensor networks with randomly occurring uncertainties. The norm-bounded uncertainty enters into the system in a random way governed by a set of Bernoulli distributed white sequence. The distributed fault estimators are designed such that, via available output measurements from not only the individual sensor but also its neighboring sensors, the fault estimation error converges to zero exponentially in the mean square while the disturbance rejection attenuation is constrained to a given level by means of the H_∞ performance index. Intensive stochastic analysis is carried out to obtain the sufficient criteria for ensuring the exponential stability and prescribed H_∞ performance. Finally, simulations are given to illustrate the effectiveness of the proposed fault estimation method.

The recurrent neural networks have wide applications in many fields such as image processing, pattern recognition, and dynamic optimization, etc. In neural networks, owning to the limit of communication capacity, time-delays often occur in the signal transmission among neurons. The time-delays under consideration include constant/time-varying delays, distributed delays and mixed delays. It is well known that time delays are the main source causing system oscillations and instability. Hence, it is of important significance to examine the influence of time-delay onto the systems stability. In the paper entitled "*H_∞ State Estimation for Discrete-time Memristive Recurrent Neural Networks with Stochastic Time-delays*" by H. Liu et al., the robust H_∞ state estimation problem is investigated for a class of memristive recurrent neural networks with randomly occurring time-delays. The randomly occurring time-delays under consideration are governed by a Bernoulli distributed stochastic sequence with known conditional probabilities. A robust state estimator is designed such that the dynamics of the estimation error is exponentially stable in the mean square and the prescribed H_∞ performance constraint is guaranteed. By utilizing the difference inclusion theory and choosing a proper Lyapunov-Krasovskii functional, the existence condition of the desired estimator is derived. Based on the proposed sufficient condition, the explicit expression of the estimator gain is given in terms of the solution to a linear matrix inequality, which can be easily tested by using the standard numerical software. The major advantages lie in that (1) it is the first time to discuss the robust H_∞ state estimation problem for discrete-time uncertain memristive recurrent neural networks and (2) the stochastic time-delays are taken into account in the framework of discrete-time memristive recurrent neural networks for the first time. Finally, a numerical example is provided to demonstrate the effectiveness and applicability of the proposed state estimation approach.

The phenomenon of ROII exists widely in various practical systems. For example, the market demand is commonly stochastic over the uncertain operation environments and the design of the optimal strategy becomes more important. In the paper entitled "*Coordination of a Supply Chain with Consumer Return under Vendor Managed Consignment Inventory and Stochastic Demand*" by Z. Wu et al., the problem of the coordination policy is studied for vendor managed consignment inventory supply chain subject to consumer return. Here, the market demand is assumed to be affected by promotional effort and consumer return policy. The optimal consignment inventory and the optimal promotional effort level are proposed under the decentralized and centralized decisions. Based on the optimal decision conditions, the markdown allowance-promotional cost sharing contract is investigated to coordinate the supply chain and there exists a suitable feasible region making supply chain members participate in the implementation of the contract. Subsequently, the comparison between the two extreme policies shows that full refund policy dominates the no return policy when the returning cost and the positive effect of return policy are satisfied certain conditions. Finally, a simulation example is given to show the impacts of consumer return policy on the coordination contract and optimal profit. Moreover, the effectiveness of the proposed supply chain decision strategy is demonstrated.

4. Acknowledgement

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