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Editorial:

Secure control and filtering for industrial metaverse

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Metaverse can be regarded as a socialized and virtualized cyberspace parallel yet interactive to the real world. Benefiting from the rapid development of cloud computing and digital twins, metaverse is transforming traditional control and filtering paradigms of industrial automation systems into cyber-physical social systems. Under this scenario, future industrial automation systems could be an integration of real-world ones and virtual twins combined with great computational power within a certain temporal and spatial range. The focused context of metaverse in this field involves information transmission management, behavior recognition of users, as well as control, filtering, and decision-making. Furthermore, the system performance and cost will be a synthetical reflection of the system behavior in cyberspace and the real world. It is indisputable that the intrinsic characteristics of information exchanges between the virtualized cyberspace and the real world, which responds to an urgent need for secure control and filtering, pose significant challenges toward guaranteeing desired system performance and realizing the ideal parameter design. Unfortunately, the current results on metaverse focus mainly on addressing its social significance and seeking its various application fields. The development in the control field still lies in its primary stage.

When information of interest is exchanged between cyberspace and the real world, malicious attacks are unavoidable, which can result in data unreliability or privacy disclosure. As such, it is of great significance to define suitable evaluation criteria to disclose the impact of cyberattacks and to provide engineering-oriented schemes of secure control and filtering. This special feature aims to advance the secure control and filtering theories and techniques in the industrial metaverse and to further promote research activities for realizing intelligent manufacturing.

Consensus represents a fundamental objective of cooperative control and finds its wide applications in multi-agent systems. In the paper entitled "*Towards resilient average consensus in multi-agent systems: a detection and compensation approach*" by Chongrong FANG et al., a deterministic detection-compensation-based consensus algorithm was developed to mitigate the adverse impact of misbehaving nodes in a distributed manner, and a stochastic extension was provided to achieve unbiased resilient average consensus in a statistical sense. In the paper entitled "*Modified dynamic event-triggered scaled formation control for multi-agent systems via a sparrow search algorithm based co-design algorithm*" by Yanping YANG et al., a co-design algorithm based on a sparrow search scheme was presented to design the control gains and triggering parameters jointly, where a resilient dynamic event-triggered mechanism was proposed to govern the information exchange. In the paper entitled "*Event-triggered distributed optimization*

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for model-free multi-agent systems" by Shanshan ZHENG et al., a model-free distributed optimization algorithm was proposed to address the consensus issue of multi-agent systems with unknown nonlinear dynamics, where the pseudo-partial-derivative matrix under event-triggered mechanisms was constructed via the received data.

Event-triggered schemes have proven to be promising in reducing energy consumption and enhancing resource utilization efficiency for resource-constrained cyber-physical systems (CPSs). The reliability and security of industrial CPSs can be greatly affected by cyberattacks or outliers. In the literature, various techniques have been developed to reduce the affected impacts on industrial CPSs. In the paper entitled "*Event-triggered finite-time command-filtered tracking control for nonlinear time-delay cyber-physical systems against cyber attacks*" by Yajing MA et al., an improved coordinate conversion was proposed by considering the attack gains and the reference signal simultaneously, and the finite-time tracking scheme was developed for nonlinear time-delayed CPSs under cyber attacks. In the paper entitled "*Outlier-resistant distributed fusion filtering for nonlinear discrete-time singular systems under dynamic event-triggered scheme*" by Zhibin HU et al., a fusion filtering algorithm was presented in terms of the inverse covariance intersection fusion rule, where a self-adaptive saturation function was used to relieve the effect of measurement outliers in data transmission. Moreover, the uniform boundedness of the filtering error was discussed, and a corresponding sufficient condition was presented. In the paper entitled "*Recursive filtering of multi-rate cyber-physical systems with unknown inputs under adaptive event-triggered mechanisms*" by Ying SUN et al., a joint recursive filtering scheme was developed to estimate both externally unknown inputs and system states for multirate CPSs. Local estimation was further fused via the covariance intersection based fusion conception.

System identification plays an important role in industrial metaverse. Noises in actual industrial processes are rarely white noises and may affect the applications of traditional identification approaches or control strategies. In the paper entitled "*Estimation of Hammerstein nonlinear systems with noises using filtering and recursive approaches for industrial control*" by Mingguang ZHANG et al., a methodology was developed to estimate neural fuzzy Hammerstein nonlinear systems by using data filtering technology and recursive approaches. Two typical nonlinear processes, i.e., the pH actual nonlinear process and continuous stirred tank reactors, were adopted to verify the effectiveness. In the paper entitled "*Asynchronous gain-scheduled control of deepwater drilling riser system with hybrid event-triggered sampling and unreliable communication*" by Na PANG et al., an effective recoil controller in networked environments was designed for a deepwater drilling riser system with nonlinear tension forces and energy-bounded friction forces, described by an asynchronous linear parameter-varying model. The prescribed H_∞ performance can be achieved when the controller gain satisfies the obtained sufficient condition.

We would like to thank all the authors for their contributions to this special feature, which will be an important asset to the field, and all the reviewers who volunteered their time to provide valuable feedback to the authors. We would also like to sincerely thank Prof. Fei-Yue WANG, an Executive Associate Editor-in-Chief of *Frontiers of Information Technology & Eelectronic Engineering*, for encouraging us to organize this special feature, and the editorial staff for the support in the entire process.

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