September 15, Wednesday (Japan Time)

10:20 – 12:20     D Room
D1: Intelligent Control and System Identification
Chair: Ms. Bing Yan (The University of Adelaide, Australia)

D1-1
ICICIC2021-003
Learning-Based Collision-Free Formation Control for Heterogeneous Multi-Agent Systems
  Bing Yan*, Peng Shi, Zhiyuan Shi and Huiyan Zhang (Australia)

D1-2
ICICIC2021-012
Tube-Based Model Predictive Full Containment Control for Stochastic Multi-Agent Systems
  Liya Li* and Peng Shi (China)

D1-3
ICICIC2021-019
On-Line Gaussian Process Model Identification of Nonlinear Systems Using Particle Swarm Optimization
  Tomohiro Hachino (Japan)

D1-4
ICICIC2021-023
Non-Fragile $H_\infty$ Control for Nonlinear Cyber Physical System with Quantized Input Signal and Cyber-Attacks
  Wenqi Shen*, Peng Shi and Huiyan Zhang (China)

D1-5
ICICIC2021-057
Locational Detection of Data Integrity Attacks with Multi-Gate Mixture-of-Experts in Smart Grid
  Xuzhen Fan*, Meng Zhang, Huijie Zeng and Chao Shen (China)

D1-6
ICICIC2021-058
Real-Time Optimization with Adaptive Velocity Estimator and Application to Signal Separation of Cell Oscillators
  Haruo Suemitsu, Shohei Ueno, Tadashi Konishi and Takami Matsuo* (Japan)

D1-7
ICICIC2021-062
Social-Welfare-Enhancing Framework Considering Individual Preferences in Theme Park Problem
  Sho Yoshioka*, Atsushi Ueno and Tomohito Takubo (Japan)

D1-8
ICICIC2021-065
Recursive Identification of Time-Varying Systems with Rapid Changing
  Lianming Sun*, Xinyu Liu and Junbiao Zeng (Japan)
Learning-Based Collision-Free Formation Control for Heterogeneous Multi-Agent Systems

Bing Yan\textsuperscript{1,*}, Peng Shi\textsuperscript{1}, Zhiyuan Shi\textsuperscript{2} and Huiyan Zhang\textsuperscript{3}

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\textbf{Abstract.} In this paper, a learning-based resource-aware control strategy is proposed for heterogeneous multi-agent systems to achieve collision-free time-varying formations under switching topologies. Without requiring any model and global communication information, a dual adaptive observer with event-triggered strategies is designed to decouple the heterogeneous dynamics from dynamic networks and reduce data transmission frequency. A model-free off-policy reinforcement learning algorithm is developed to solve the robust collision-free formation control problem, capable of solving the non-quadratic optimization problem with unknown model information. Simulation is conducted for bushfire tracking and patrolling time-varying formations to verify the effectiveness of the proposed formation control strategy. 

\textbf{Keywords:} Formation control, Event-triggered observer, Reinforcement learning, Heterogeneous multi-agent systems

Tube-Based Model Predictive Full Containment Control for Stochastic Multi-Agent Systems

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\textbf{Abstract.} This paper develops a tube-based distributed model predictive full containment control (TDMPFCC) algorithm for leader-following systems with bounded disturbance and dynamic leaders, which employs knowledge about constraints on states and control inputs to extrapolate their admissible values in the entire predictive horizon. Kalman filter is introduced for the output feedback control, resulting in estimated error, along with which, the disturbance is involved in the time-varying tubes to construct the tightened constraints. For each follower, by penalizing the control difference with its neighbors and the deviation of the states from the convex hull produced by its neighbors’ corresponding states, a TDMPFCC problem subject to the tightened constraints is optimized only
utilizing the local nominal state and control sequences. The TDMPFCC algorithm leads to a stable full containment by applying the optimal solution, based on which, the recursive feasibility and robust stability are proved by designing proper distributed terminal controller and constraints. Finally, the effectiveness and robustness of the proposed method are illustrated by numerical example.

**Keywords:** Multi-agent systems, Distributed model predictive control, Full containment, Output feedback control, Dynamic leaders

**D1-3: ICICIC2021-019**

**On-Line Gaussian Process Model Identification of Nonlinear Systems Using Particle Swarm Optimization**

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**Abstract.** This paper presents a novel on-line Gaussian process (GP) model identification of nonlinear systems using particle swarm optimization (PSO). The GP is a Gaussian random function whose values follow a multidimensional normal distribution, and is specified by its mean function and covariance function. The identification model of the objective system is derived by using the GP. PSO is applied to the on-line training of the GP prior model by minimizing the negative log marginal likelihood of the time-shifted input-output data set. The nonlinear part of the objective system and its confidence region are evaluated by the predictive mean and predictive covariance of the GP posterior, respectively. The results of on-line identification for a simplified power system are shown to demonstrate the effectiveness of the proposed method.

**Keywords:** Identification, On-line, Gaussian process, Nonlinear system, Particle swarm optimization

**D1-4: ICICIC2021-023**

**Non-Fragile $H_\infty$ Control for Nonlinear Cyber Physical System with Quantized Input Signal and Cyber-Attacks**

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**Abstract.** This paper studies the design of a non-fragile $H_\infty$ controller for a discrete-time uncertain T-S fuzzy system with control input quantization and cyber attacks. By using the Lyapunov function
method related to the membership function, a low conservative result is obtained, and the design conditions of the quantified non-fragile controller of the uncertain T-S fuzzy system are given using the LMI technology. By solving these LMIs, the required non-fragile controller can be constructed. The designed non-fragile controller can ensure the global exponential stability of the uncertain fuzzy system and meet the $H_\infty$ performance index.

**Keywords:** Cyber physical system, Attacks, Nonfragile, Quantization, $H_\infty$ control

### D1-5: ICICIC2021-057

**Locational Detection of Data Integrity Attacks with Multi-Gate Mixture-of-Experts in Smart Grid**

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**Abstract.** In recent years, data integrity attacks have gradually become a major threat to the security of smart grid. The presence detection and locational detection of data integrity attacks are of vital significance for repairing vulnerable points, but the latter is rarely studied. The multi-task classification problem for locational detection of data integrity attacks is formulated in this paper. Based on the formulation, the locational detection with multi-gate mixture-of-experts (LD-MMoE) scheme is proposed. When reaching similar detection performance, the number of LD-MMoE’s trainable parameters is less than that of the state-of-the-art study, which indicates the proposed LD-MMoE scheme is more computational cost-friendly. Simulations conducted on the IEEE 14-bus system and 118-bus system verify the effectiveness of the proposed LD-MMoE scheme.

**Keywords:** False data injection attack, Locational detection, Multi-gate mixture-of-experts, Multi-task learning, Smart grid

### D1-6: ICICIC2021-058

**Real-Time Optimization with Adaptive Velocity Estimator and Application to Signal Separation of Cell Oscillators**

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**Abstract.** This paper extends the momentum method using an adaptive differential filter to the measurement-based optimization of an objective function with multivariable decision variables. The proposed method is a model-free real-time optimization algorithm with switching. Further, we define the signal separation problem from the dynamics of multi-cells to that of a single cell based on the assumption that the sum of the CO\(_2\) uptakes of a crassulacean acid metabolism plant is a linear combination of delayed oscillation waves of cells. We apply the proposed momentum method to estimating delay sequences of CO\(_2\) uptakes. Finally, we perform simulations using MATLAB/Simulink to verify the proposed method.

**Keywords:** Crassulacean acid metabolism, Time delay estimation, Momentum optimization method
Social-Welfare-Enhancing Framework Considering Individual Preferences in Theme Park Problem

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Abstract. The theme park problem is a kind of resource allocation problem. The goal of this type of problem is to improve social system composed of individuals. Some methods have been proposed for reducing the traveling time. However, there are few methods for directly increasing social utility in theme parks. In a real theme park, individual utilities of visitors are usually different from each other. In this paper, we propose a method to enhance social welfare considering individual preferences. In the proposed method, each user determines his/her own preferences which represent the priority of individual utilities. This framework guarantees the visitors' individual optimalities in the meaning of maximizing total utility that they get, and it has the potential to enhance the social welfare. Computer experiments show that the proposed method causes better results.

Keywords: Social-welfare-enhancing, Individual preferences, Theme park problem, Mass user support, Resource allocation problem, Multiagent systems, Statement-based cost estimate

Recursive Identification of Time-Varying Systems with Rapid Changing

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Abstract. The characteristics of some practical systems vary with time and the time-varying models are required to be identified promptly from the observation data in the applications of adaptive design and system monitoring. In the recursive identification algorithms based on the parameter approximation of cosine series (RCS), the time-varying parameters are approximated by cosine series (CS), and the parameter estimation problem becomes estimation of CS coefficients. However, Gibbs effect, which occurs at the discontinuous points, causes parameter fluctuation in CS approximation, and deteriorates the estimation accuracy of RCS. In order to improve the identification performance, a novel approach to reduce the influence of Gibbs effect in CS approximation is investigated in this paper. Detection of abrupt variation points through a neural network is introduced into the recursive identification algorithm, and the CS approximation is compensated at the detected abrupt variation points to reduce the estimate fluctuation, then the compensated approximation leads to better identification performance for the time-varying systems with rapid changing. The implementation and its effectiveness of the proposed algorithm are demonstrated by numerical simulation examples.

Keywords: Cosine series, Gibbs effect, Time-varying system, Recursive identification