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# Editorial: Special Issue on Autonomous Systems and Automation Technologies, Dedicated to Professor Zongli Lin's 60th Birthday

It is our great pleasure and honor to organize this Special Issue on Autonomous Systems and Automation Technologies in honor of the 60th birthday of our long-time colleague and friend, Professor Zongli Lin of the University of Virginia, USA.

Professor Lin obtained his B.Sc. in mathematics and computer science in 1983 from Xiamen University, China; M.Eng. in automatic control in 1989 from the Chinese Academy of Space Technology, China; and Ph.D. in electrical and computer engineering in 1994 from Washington State University, Pullman, Washington, USA. He joined the Department of Applied Mathematics and Statistics, State University of New York at Stony Brook, USA, in 1994. In 1997, he moved to the Department of Electrical and Computer Engineering at the University of Virginia, Charlottesville, USA, where he currently holds a Chair Professorship.

Professor Lin has remained active in his research and professional service and leadership throughout his career. In research, his work has spanned the general area of control theory and its applications. His research results have led to numerous publications, including seven books and over 700 papers and book chapters. Among the significant services and leadership that he has provided in our professional communities are his service in numerous journal editorial boards, including *IEEE Transactions on Automatic Control*, *Automatica* and *Unmanned Systems*. He is the series editor of the Springer book series Control Engineering. He has also contributed to the organization of numerous conferences in our field and will be the general chair of the 2028 American Control Conference. He was elected a member of the Board of Governors of the IEEE Control Systems Society (CSS) and chaired the IEEE CSS Technical Committee on Nonlinear Systems and Control. For his fundamental contributions to control theory and applications, excellent teaching, and exemplary services to professional societies, Professor Lin was elected a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), International Federation of Automatic Control (IFAC), the American Association for the Advancement of Science (AAAS), and the Chinese Association of Automation (CAA).

The research outcomes of Professor Lin have had significant impacts on the field of control theory and applications, stimulated a number of new research topics continuing to be investigated. This special issue collects 18 papers from Professor Lin's former classmates, collaborators and friends. We hope this special issue will not only reflect the current research activities on topics related to autonomous systems and automation technologies but also point to some new directions for further exploration. A brief introduction to the manuscripts included in this special issue is given as follows.

The work by T. Wang and J. Huang [1] on event-triggered distributed observer for a rigid body leader system has further enhanced the technique proposed by the authors in designing an event-triggered distributed observer over jointly connected networks by assuming that the communication network is acyclic. The result is applied to solve the leader following consensus problem of multiple uncertain rigid body systems.

The work by Y. Zhou *et al.* [2] on learning multi-modal scale-aware attentions for efficient and robust road segmentation proposes a Multi-modal Scale-aware Attention Network (MSAN) to fuse RGB and Depth data effectively via a novel transformer-based cross-attention module, namely multi-modal scare-aware transformer (MST), which fuses RGB-D features from a global perspective across multiple scales, and a Scale-aware Attention Module (SAM) that captures channel-wise attention efficiently for cross-scale fusion. These attention-based modules explore the complementarity of modalities and scales, narrowing the gaps and avoiding complex structures for road segmentation.

The work by J. Xin *et al.* [3] on efficient real-time path planning with self-evolving particle swarm optimization (PSO) in dynamic scenarios proposes a Tensor Operation Form (TOF) that converts particle-wise manipulations to tensor operations, thereby enhancing computational efficiency. Harnessing the computational advantage of TOF, a so-called Self-Evolving Particle Swarm Optimization (SEPSO) is developed to achieve real-time performance on dynamic path planning.

The paper by L. Xia and J. Su [4] proposes an active disturbance rejection predictive control strategy for trajectory planning task of unmanned ground vehicles. An internal error and environment disturbance are processed via single extended state observer and a nonlinear feedback control law is applied to reduce steady state error. The motion planning and nonholonomic constraints are then handled via a nonlinear model predictive control scheme to accomplish trajectory planning task with internal error and environment disturbance.

The paper by D. Cheng, X. Zhang and Z. Ji [5] on the transition system representation of Boolean control networks proposes a transition system (TS) framework for the analysis and design of logical networks. The formula for calculating the fixed points and cycles of a transition system is first provided. Then, the transition system representation of Boolean networks (BNs) and Boolean control networks (BCNs) is introduced. The method is applied to design output robust controls of logical networks.

The article by J. Guo, Y. Zhang and J.-F. Zhang [6] presents a novel finite-and-quantized output feedback asymptotic tracking control method for a general class of continuous-time linear time-invariant systems. The proposed method combines the advantages of classical pole placement control technique and finite quantization feedback technique, which not only reduces the requirement for feedback information compared with existing tracking control methods but also effectively handles unstable poles and zeros in controlled systems, thereby achieving asymptotic output tracking.

The paper by X. Li *et al.* [7] on a geometry-based distributed connectivity maintenance algorithm for discrete-time multi-agent systems with visual sensing constraints presents a novel approach to address the challenge of maintaining connectivity within a multi-agent system when utilizing directional visual sensors. Their approach, grounded in geometric principles, leverages a mathematical model of directional visual sensors and employs a gradient-descent optimization method to determine the position and orientation constraints for each sensor based on its geometric configuration. It ensures network connectivity.

A particle fusion approach for distributed filtering and smoothing by T. X. Lin *et al.* [8] addresses issues on distributed state estimation for coordinated team decision-making, which typically involves sharing information between robots in order to outperform individual state estimation. To outcome the shortfall of an ill-defined pointwise product operation in particle-based distributions, they propose a drop-in replacement based on using the generalized Holder's inequality to upper-bound the product over a series of grid cell sets that discretize the state space. As a result, they are able to achieve an impressive improvement in the position tracking error.

Inspired by the primitive property of convergent force field, the manuscript by S. Zhong *et al.* [9] on controlling musculoskeletal system with spinal cord-inspired constraint force field primitives proposes a new algorithm to efficiently construct constraint force field on musculoskeletal system with highly redundant actuators by taking optimized parameters of constraint force field as motor primitives. It is able to reduce the dimension of the solution space so as to effectively improved the computational efficiency of constructing constraint force field in musculoskeletal system with redundant muscles.

The work by J. Liu *et al.* [10] on a distributed optimization approach for collaborative object lifting using multiple aerial robots recasts the collaborative object lifting challenge into an optimization problem framework. Within their setup, each robot leverages a local evaluation function to determine its lifting location. Collectively, these robots strive to optimize a unified evaluation function. An intertwined equation constraint is embedded within the optimization schema, ensuring that the system's mass center remains stable throughout the lifting process.

The manuscript by M. Wang and Z. Sun [11] on the safety-critical stabilizing design of switched linear autonomous systems addresses the stabilization problem under safety-critical constraints for continuous-time switched linear autonomous systems. Given an origin-symmetric region that any state trajectory should be stayed, it seeks to design a switching law to achieve both stability and safety.

The manuscript by X. Zhao *et al.* [12] considers a multi-objective resource allocation problem for a multi-agent network where each agent has multiple local objective functions. It is to obtain the Pareto optimum by exchanging information between agents. The effectiveness of the proposed algorithms is demonstrated by a microgrid network example.

The manuscript by Z. Chen, G. Chen and Y. Hong [13] on defense for advanced persistent threat with inadvertent and malicious insider threats proposes a game theory framework to solve advanced persistent threat problems, especially considering two types of insider threats: malicious and inadvertent. Within this framework, they have established a unified three-player game model and derive Nash equilibria in response to differing types of insider threats and provided quantitative solutions to advanced persistent threat problems pertaining to insider threats.

The paper by W. Bai *et al.* [14] presents a novel sequential model predictive control framework for coordinated operation of virtual coupling high-speed trains. It deals with the coordinated control problem of the multiple high-speeds operating under the virtual coupling mode with special consideration of the coupled safety intertrain distance constrains and other independent constraints affecting train dynamics.

The manuscript by T. Zhang *et al.* [15] introduces a visual observer-based state-feedback control tailored for autonomous motion on SE(3) to address challenges posed by modeling uncertainties and measurement noise. The proposed approach unfolds in two fundamental phases. In the initial stage, the visual observer, based on modeling information, visual sensors, and pre-deployed landmarks, along with the state-feedback controller, are developed independently, underpinning their individual semi-global practical asymptotic (SPA) stability. The latter stage applies the well-established Small Gain Principle to regulate observer and controller parameters to guarantee the SPA stability of the closed-loop system with the visual-observer based state feedback control.

Random mobility models (RMMs) capture the statistical movement characteristics of mobile agents and play an important role in the evaluation and design of mobile wireless networks. The work of T. Li *et al.* [16] uses RMMs to model the movement of Unmanned Aerial Vehicles (UAV) as the platforms for airborne communication networks. They develop a generic method to estimate RMMs that are composed of these two types of random variables, which describes the movement characteristics for each maneuver and characterizes how often the maneuvers are switched, respectively.

The work of X. Liu *et al.* [17] presents a fairly complete process for developing an unmanned morphable aerial-aquatic vehicle system, TJ-FlyingFish. It includes an innovative design methodology of the aerial-aquatic platform and the cross-medium localization, dynamics modeling, and flight control systems as well as a sophisticated multi-sensor-based cross-medium localization system that combines SLAM, sensor synchronization, and data capture mechanisms, enabling seamless transitions between aerial and aquatic environments, and supporting autonomous operations. The results are fully validated through actual experiments.

In recent years, drones have found increased applications in a wide array of real-world tasks. The work of Z. Feng *et al.* [18] addresses the challenge of controlling a drone as it traverses a swinging gate characterized by unknown dynamics. It introduces a parameterized MPC approach named hyMPC that leverages high-level decision variables to adapt to uncertain environmental conditions. The effectiveness of hyMPC is validated through numerical simulations, demonstrating its capability to achieve safe and precise flight with limited prior knowledge of environmental dynamics.

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*Special Issue Editors*
Jie Chen
Tongji University

Jie Huang
Chinese University of Hong Kong

Ben M. Chen
Chinese University of Hong Kong

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