Guest Editorial

With continuous growth in the complexity, scale, and dynamics of space systems, *information integration* (II) becomes an essential strategy for managing system complexity and tackling dynamic changes and uncertainties in space missions [1], [2], [3]. *Space II* (SII) is in high demaind so as to meet the system requirements of latency, heterogeneity, communication, networking, security, and resilience. The study of SII has attracted much attention from scientists and engineers across all engineering domains. We proposed this *special section* (SS) to solicit, identify, and disseminate new contributions to the theories, methodologies, tools, and case studies of SII that are developed to address some unique challenges of space systems such as security, safety, reliability, and resilience and help T-AES readers gain a basic understanding of the cutting-edge space technologies and the directions of future advancement of SII. The editorial team has received 33 high-quality submissions from around the world, and a total of 21 manuscripts were ultimately accepted through a rigorous peer-reviewing process.

I. MAIN CONTRIBUTIONS OF ARTICLES IN SS

The accepted articles in this SS have shown a high diversity in research topics, methodologies, and objectives. Their main contributions are summarized in four categories as follows [4].

A. Artificial Intelligence and Machine Learning

In Yao et al. [A2], the authors proposed a demising image approach based on patch processing. Particularly, patch-based denoising algorithms under the low-rank (LR) model show outstanding performance in wireless transmission. A patch-based composite method for image denoising named similar patch LR(SPLR) introduces a nonlocal model and structural similarity index measure (SSIM) to evaluate patch similarity. In [A3], the author investigated an aviation cable fault detection and location method, augmented spread spectrum time-domain reflectometry (AS-STDR), to detect soft faults effectively. First, the SSTDR results are decomposed into some intrinsic mode functions (IMFs) using the improved variational mode decomposition (VMD) and select the IMF with the highest kurtosis to analyze. Second, short-time Fourier transform (STFT) is applied to deal with the selected IMF to enhance the amplitude characteristics. Finally, experiments with different fault types and fault degrees verify the approach's effectiveness. In [A4], the authors described an open-source benchmark for space noncooperative object visual tracking, including a

simulated environment, evaluation toolkit, and an algorithm using deep reinforcement learning. In [A6], the authors investigated an integrated optimization problem of aircraft assembly scheduling and flexible preventive maintenance with decision making, in which both machine and worker flexibility are considered.

Furthermore, an improved double-layer Qlearning algorithm with decision making is responsible for learning a proper machine selection heuristic from the given action set to ensure the machine load balance. In [A20], a microcrack defect in the terminal electrode of the tantalum capacitor was studied using machine learning. This article proposes a detection model with outline profile-guided feature augmentation and attention-based multiscale fusion to form a MicroCrack-Net to improve the performance of detecting microcracks. In this new method, the microcrack outline is utilized to guide the lossless feature extraction to strengthen unobvious microcrack features without pooling operation to avoid information loss of tiny defects during layer-by-layer processing in the convolutional neural network.

B. Sensors, Signal Processing, and Communication Network

In [A1], the authors divided the software defined network (SDN) control plane into two layers, the primary controller layer was deployed on the ground network, and the secondary on the space-based network. The SDN data plane comprised space, air, and ground-based networks. Second, a multiobjective optimization model was constructed considering the average network delay and the controller load. Finally, a multiobjective optimization solved by genetic algorithm searching is adopted to improve the global search. In [A5], the Ionospheric scintillation phenomenon is investigated. Modeling this phenomenon is quite complex due to the influence of several other aspects, such as the geomagnetic and solar activities, the seasons, and the geographic location. The authors proposed to develop short-term predictive models about amplitude ionospheric scintillation through machine learning techniques. The dataset was built considering information related to geomagnetic, solar, and interplanetary activities, the phenomenon's temporal and geographic dependence, and the ionosphere's state. Six models were used based on three algorithms, the artificial neural network, the extreme gradient boosting, and the random forest. In [A10], a new approach is used to evaluate remote photometric observations, especially unary asteroids, and provide an efficient and convenient way to discover binary asteroids. For this problem, this article proposes to simulate unary and binary asteroid systems using celluloid and oblate sphere shape models and generate the corresponding light curve brightness information with different asteroid physical parameters improving the identification and evaluation of different asteroids. In [A11], to achieve high-accuracy navigation for deep space probes, the measurement relies on the corrections from the estimation of reference weak Quasar signal, which is guided by the forecasting data compensation. However, disturbed by the interference, the forecasting data sometimes is unavailable. This article used an intelligent 2-D chart method with autodetection for measurement without forecasting data support. In [A13], the authors propose the dynamic event-triggered control (ETC) and self-triggered control (STC) to achieve the semiglobal finite-time stabilization of spacecraft rendezvous system with input constraints. Based on the Clohessy Wiltshire equation, a bounded dynamic ETC algorithm is first designed. The time-varying control gain will approach infinity at a finite time and only be scheduled at a specified time determined by a dynamic event-triggered mechanism. The algorithm is found to save communication resources and to be effective and efficient. In [A6], this article described the design of a hyper-redundant manipulators sensor for applications in confined spaces such as on-orbit services. It can traverse freely, manipulate objects flexibly, and conform to curvilinear paths accurately in confined spaces.

C. Unmanned Vehicles, Drones, Satellites, and Remote Sensing

In [A8], path planning in space systems has become a research hotspot for maintaining its safety, security, and reliability. To explore the passable path connecting the starting point and the target point, and optimize a smooth trajectory that can be tracked by unmanned aerial vehicles (UAVs) in 3-D space, a skeleton extraction and greedy algorithm based has been proposed to guide the flight of UAVs. In [A12], landform identifications are important for aerial vehicles, satellites, and spacecraft. In this article, the authors developed a multitype landform detection system based on a lightweight deep learning framework, which has quite a small model size but presents excellent performance. The proposed framework was trained and tested on images with different scales collected from various locations in HiRISE database. In [A14], the authors studied the availability and accuracy of positioning, navigation, and timing, the traditional global navigation satellite system (GNSS) algorithms and models performances under different signal conditions. They conducted a systematic analysis to understand the research's extent in utilizing machine learning models in GNSS and their performance. In [A18], the authors investigated autonomous driving on the natural paths of planets. They proposed a new approach based on an improved deep deterministic policy gradient (DDPG) framework for autonomous driving on rough roads requires handling uneven surfaces of different throttle and braking reaction speeds. It was found that the method has better performance than previous algorithms, which can improve the utilization of the driving experience on a natural path and increase the learning efficiency of the strategy. In [A19], the authors present a framework of multi-UAV multitask allocation and trajectory planning with collision avoidance. The scenario of interest is where multiple UAVs are launched to investigate selected targets in a massive wildfire disaster relief terrain. An informative exploratory search mechanism is developed that provides the exploration trajectories to

precisely locate the wildfire positions in the wildfire environments. UAVs are deployed to multiple target positions, and a spatial dislocation scheme is developed for effective collision avoidance.

D. Knowledge Management, Internet of Things (IoT), and Big Data Analytics

In knowledge management, context awareness is one of the most interesting research topics. The authors in [A9] described a new approach to support on-obit missions using the knowledge of industrial information integration. Reactive planning is a critical function in solving dynamic problems during task execution to ensure mission success, relying on understanding the situation for optimal decision-making. The authors proposed a context-awareness model enhancement framework to identify the triggers of critical conditions based on event evolution-based analysis of the spacecraft. In [A15], the authors proposed instant contextualized travel-related factors to model air passengers' ancillary services, thus achieving dynamic recommendations. It also presents a four-tuple to construct a contextual ontology as a conceptual model of ancillary aviation services. In [A16], the authors proposed collaborative filtering (CF) as an effective solution to IoT service discovery. However, deploying a CF framework in real-world distributed IoT systems poses another significant challenge regarding reliability assurance and privacy protection. To bridge this gap, they propose an innovative integrated collaborative filtering framework incorporating the location-aware quality of IoT services into a heterogeneous graph embedding model. In [A17], the authors attempt to address the problem of a large amount of spatial data using nonshared and imbalanced unsupervised domain adaptation from the labeled big data, where nonshared classes mean the label space out of the target domain. Previous methods proposed integrating the semantic knowledge of big data to help the unsupervised domain adaptation for sparse data. This approach leverages prior hierarchy knowledge to enhance domain contrastive aligned feature representation with graph reasoning.

II. CONCLUSION

A wide scope of the responses to this SS from so many scholars in multiple disciplines has confirmed that advancing SII is challenging but crucial to meet some unique requirements of complex space systems in terms of latency, heterogeneity, communication, networking, security, and resilience; many research problems remain unsolved, newly developed information technologies should be widely explored in SII for sensing, communication, networking, data mining, and decision-making supports of complex space information systems [4]. The editorial team would also take this opportunity to express great appreciation to all the authors for sharing their valuable works and to all reviewers for providing constructive recommendations in selecting and improving articles. The editorial team especially thanks Editor-in-Chief, M. Rice, and the Journals Production Manager, S. M. Turk, of the IEEE TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS (T-AES), for their great support throughout the entire process, from the proposal review to the final publication of SS.

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APPENDIX
RELATED ARTICLES

[A1] C. Chen, Z. Liao, Y. Ju, C. He, K. Yu, and S. Wan, "Hierarchical domain-based multi-controller deployment strategy in SDN-enabled space-air-ground integrated network," *IEEE Trans. Aerosp. Electron. Syst.*, vol. 58, no. 6, pp. 4864–4879, Dec. 2022.

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[A3] X. Shi, R. Li, H. Zhang, H. Zhao, and Y. Liu, "Application of augmented spread spectrum time domain reflectometry for detection and localization of soft faults on a coaxial cable," *IEEE Trans. Aerosp. Electron. Syst.*, vol. 58, no. 6, pp. 4891–4901, Dec. 2022.

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[A12] S. Jiang, K. L. Yung, W. H. W. Ip, Z. Lian, and M. Gao, "Automated detection of multi-type landforms on mars using a lightweight deep learning-based detector," *IEEE Trans. Aerosp. Electron. Syst.*, vol. 58, no. 6, pp. 5015–5029, Dec. 2022.

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