Guest Editorial Special Issue on Integrated Computing: Computational Intelligence Paradigms and Internet of Things for Industrial Applications

RECENTLY, Integrated computing (IC) provides a promising solution to the industry for building the Internet of Things (IoT) systems and make innovation at a rapid pace. The new era of IC with reference to IoT for Industrial applications has three main components: 1) intelligent devices; 2) intelligent system of systems; and 3) end-to-end analytics. This Special Issue is integrating computational intelligence (CI) paradigms, advanced data analytics optimization opportunities to bring more compute to the IoT. CI paradigms are more appropriate for handling uncertainty and complexity of solving real work problems compared to traditional statistical approaches and tools presently being utilized. In fact, recent literatures have addressed the inherent power of fusion of CI approaches. Moreover, it can provide the effective solutions for machine understanding of data (structured/semi structured), optimization problems, specifically, dealing with incomplete or inconsistent information, with limited computational capability related to IoT.

This Special Issue mainly focused on IC aspects, recent developments of and their diverse IoT applications as well as theoretical studies. Besides, we can consider CI-based re-enforcement paradigms and predictive learning algorithms are more applicable to IoT datasets, time series data from IoT devices with sensor fusion and streaming. Furthermore, there are many noteworthy issues such as data management, data analytics, resource management, decision automation that need to be addressed in the view of CI and meta-heuristic algorithms with relate to IoT. This Special Issue intends to give an overview of state-of-the-art of issues and solution guidelines in the new era of IC with CI approaches and optimization techniques for IoT. This Special Issue solicits high-quality original research papers which present novel in-depth fundamental research contributions either from a methodological/application perspective in understanding CI paradigms and their capabilities in solving a diverse range of problems in IoT and its real-world industrial applications. We have received a total of 42 submissions, and after two rounds of rigorous review, seventeen papers were accepted.

The paper "MVO-Based 2-D Path Planning Scheme for Providing Quality of Service in UAV Environment" by Kumar *et al.*, presented gradient free meta-heuristic algorithms such as ant lion optimizer, dragonfly algorithm, grey wolf optimizer, moth flame optimization, whale optimization algorithm, and multiverse optimizer (MVO) are compared to ascertain an optimized traversal path for unmanned aerial vehicles in 2-D space. Effectiveness of these algorithms has been compared on the basis of convergence rate, distribution of the fitness function values, and computation efficiency. MVO showed superior performance in comparison to other existing algorithms. It can be seen that the exploration and exploitation processes of the MVO in path planning is superior to the other state-of-the-art meta-heuristic algorithms.

The paper "EH-HL: Effective Communication Model by Integrated EH-WSN and Hybrid LiFi/WiFi for IoT" by Sharma *et al.*, proposed the novel communication model technique by integrating energy harvesting wireless sensor network and hybrid LiFi/WiFi communication technologies to make smart homes/industries more efficient and green for IoT. The proposed model is capable of efficiently transmitting data at high speed for bidirectional multidevice and by harvesting energy, provides the power to the sensor nodes. To synchronize multidevice transmissions, transmit data, and provide low-cost wireless communication, this paper used the color beams of the RGB LEDs. The result of the evaluation shows that the hybrid communication scheme has been proposed in the EH-HL model. It also offers superior performance and achieves a data rate of 25 Mb/s for multiaccess/multiusers.

The paper "Multiobjective Optimization in 5G Hybrid Networks" by Omar *et al.*, investigated the downlink performance of a three-tier heterogeneous network (HetNet) that consists of sub-6 GHz macrocells overlaid with small cells operating on both the mmWave and sub-6 GHz bands. A model is developed using tools from stochastic geometry to analyze the coverage, rate, ASE, and EE of such a network. Various deployment strategies and their impacts on the considered metrics has been studied in this paper. The effects of the deployment parameters, such as BS density, on coverage probability, rate, spectral efficiency, and energy efficiency were addressed.

The paper "A Robust and Energy Efficient Authentication Protocol for Industrial Internet of Things" by Li *et al.*, proposed a robust and energy efficient three-factor authentication protocol for Wireless Sensor Networks. Experimental analysis show that proposed approach can prevent most common

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attacks and provides some ideal functionality. Furthermore, the security and performance comparisons address that the proposed protocol is robust than other similar protocols with low computational cost. In addition, it reduces the power consumption and computational cost of the sensor nodes by adopting appropriate communication model and lightweight algorithms. Thus, this paper highlighted the significance of proposed protocol robustness and efficiency in IoT applications.

The paper "An Energy-Efficient Multiobjective Scheduling Model for Monitoring in Internet of Things" by Mostafa *et al.*, addressed the optimized scheduling of the monitoring role in resource-constrained embedded devices for IoT networks to minimize the energy consumption as well as the communication cost of monitoring. The proposal model has tested on randomly generated instances and the experimental results illustrate the effectiveness of the proposed model to optimize the scheduled monitoring of IoT networks. In addition, this paper presented a three-phase mathematical model to address the optimized scheduling of the monitoring role of the nodes in IoT networks. The proposed solution was indeed effective in achieving the monitoring objective while minimizing the cost of monitoring in terms of the energy and communication costs and the number of nodes' state transitions.

The paper "Edge Computing-Based Intelligent Manhole Cover Management System for Smart Cities" by Jia *et al.*, proposed an edge computing-based intelligent manhole cover management system (IMCS) for smart cities. A unique radio frequency identification tag with tilt and vibration sensors is used for each manhole cover, and a narrow-band IoT is adopted for communication. The implementation of the proposed IMCS has been tested in the Xiasha District of Hangzhou, China, showed its high efficiency and reduced the average repair time, which could improve the security for both people and manhole covers.

The paper "Joint Range-Doppler-Angle Estimation for Intelligent Tracking of Moving Aerial Targets" by Wan *et al.*, proposed compressed sensing algorithms for angle-range-Doppler estimation in intelligent tracking systems when the direct path is known and unknown, respectively. This work aims at developing a joint range-Doppler-angle estimation solution for an intelligent tracking system with a commercial frequency modulation radio station (noncooperative illuminator of opportunity) and a uniform linear array. Simulation result shows that the proposed solution can effectively detect weak targets in an iterative manner. The performance of the proposed solution has been validated via real test.

The paper "Optimization Algorithms for Multiaccess Green Communications in Internet of Things" by Zhai *et al.*, focused on the total power minimization problem in IoT with multiaccess communications. This paper has formulated a nonconvex problem according to the Shannon capacity formula with power and sum of interference signal power constraints, which is transformed from the power domain into the rate domain later. This paper has convexified it by leveraging the reformulation approximation technique and nonnegative matrix theory to obtain a convex optimization problem with rate as the only variable. Numerical simulations demonstrated that importance of the proposed algorithms can achieve the efficient power and rate allocations.

The paper "An Effective IoT Service-to-Interface Assignment Algorithm via Search Economics" by Tsai and Liu, presented a modified version of search economics (SE) to solve the service-to-interface assignment of multiple IoT devices because resource allocation algorithms need an integrated perspective to find out better solutions to cut down the overall cost of devices satisfying different demands. The main differences between the proposed algorithm (SESIA) and SE are: the way the solutions are encoded and the way the transition operator is designed. The simulation results show that the proposed algorithm is able to find out better results for most service-to-interface assignment of multiple IoT devices problems.

The paper "Loss-Tolerant Event Communications Within Industrial Internet of Things by Leveraging on Game Theoretic Intelligence" by Esposito *et al.* presented a clustered lightweight gossiping algorithm for resilient event-based communications among the sensors, without requiring a predeployed brokering infrastructure supporting the adopted publish/subscribe protocol. A simulation-based assessment has been performed in order to empirically show the improvements in terms of successfully delivered notification without the excessive costs of the state-of the-art solutions available in the literature.

The paper "Internet of Things (IoT): Research, Simulators, and Testbeds" by Chernayshev *et al.*, discussed recent research trends in the IoT area along with current challenges faced by the IoT research community. Then, this paper presented a comparative analysis of current simulation tools and actual IoT testbeds that have been adopted by researchers for conducting IoT research. Finally, this paper outlined a few open challenges of current IoT simulators and testbeds that need to be addressed by the IoT research community to conduct largescale, robust and effective IoT simulation and emulation tests.

The paper "When Computation Hugs Intelligence: Content-Aware Data Processing for Industrial IoT" by Zhou *et al.*, studied the performance implications of different computing manners in the environment of IIoT. On the theory end, this study have analyzed the relationship between the transmitted data and the energy consumption which results from the data processing and transmission. Importantly, this study derived an exact expression for the stochastic fluid model and characterizes the performance of the IIoT. Numerical results demonstrate that the proposed computing manner is robust to variable IIoT environments.

The paper "Driver's Intention Identification and Risk Evaluation at Intersections in the Internet of Vehicles" by Chen *et al.*, proposed a collision probability estimation model at intersections. This study have used BP neural network to build the driver's intention model and then select the intention with the maximum probability as the identified intention. Then, the identified probability is taken as the control matrix of the Kalman filter, by which the trajectory of each vehicle is predicted. Finally, the collision probability model at the intersection is given. Numerical results show that the

proposed model has high precision and outperform traditional time to collision model in terms of risk recognition ability and prediction precision.

The paper "Intelligent IoT Traffic Classification Using Novel Search Strategy for Fast-Based-Correlation Feature Selection in Industrial Environments" by Egea *et al.*, reviewed some feature selection filters based on correlation measurements, and proposed a novel approach for providing new functionalities to the FCBF algorithm in order to improve IoT-based intelligent networks in facilities. This study has highlighted the modification of the original FCBF algorithm by changing the evaluation method of the redundancy and including a scoring process for ranking the variables.

The paper "A Robust Features-Based Person Tracker for Overhead Views in Industrial Environment" by Ahmed *et al.*, proposed a more effective and robust algorithm for tracking people in videos obtained through camera installed overhead of the motion space. These video frames obtained through these cameras are scanned for motion blobs which are then scanned through rHOG algorithm for efficient detection of person. The trajectories of detected person are used to predict the next position of the person in the subsequent frame using the history of the currently tracked person. This study has used five different test sequences of varying complexity and compares the results of the proposed algorithm with four standard tracking algorithms. Simulation results show that the proposed algorithm achieved far more significant results than the existing algorithms.

The paper "Safe-aaS: Decision Virtualization for Effecting Safety-as-a-Service" by Roy *et al.*, presented solution for the development of a novel infrastructure, Safety-as-a-Service (SafeaaS) for the road transportation industry. The proposed system architecture provides safety related decisions to multiple end users at the same time instant using decision virtualization. Analytical results show the cost and profit analysis of end-users, sensor owners, and SSP. This study observed the profit gain by mobile sensor owner is 19.69% more as compared to static sensor owner. In the presence of 5, 10, and 15 end-users, payable rent varies between 15%–20%. Additionally, in order to depict a clear view of usage of SafeaaS presented via two case studies.

The paper "Reducing the Cooling Power of Data Centers by Intelligently Assigning Tasks" by Yang *et al.*, constructed a power model to correlate task assignment, heat recirculation, inlet temperature, and the power consumed by cooling system for both homogeneous and heterogeneous data centers. Based on the proposed power model, genetic simulated annealing is proposed to intelligently assign tasks across the corresponding data center, thus reducing the power consumption of cooling system in the data center. Experimental results indicate that the proposed approach can effectively decrease the temperature requirement of supplied cold air and reduce the power consumption of the cooling system in contrast to the traditional genetic algorithm and ant colony algorithm, especially when the data centers are with medium utilization.

We express our sincere thanks to the authors for their significant contributions to this Special Issue. We would like to give our gratitude for all reviewers dedicating their time in reviewing these papers, and for their valuable comments and suggestions that significantly improve the quality of the articles. We hope that this Special Issue will serve as good reference for researches, scientists, engineers, and academicians in the field of CI in Industrial IoT systems. Also, we would like to express our sincere gratitude to the Editor-in-Chief, Prof. S. Shen, for giving this prospect and lots of assistance throughout the process.

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