Guest Editorial
Special Issue on Cognitive Internet of Things

COGNITIVE Internet of Things (IoT) is the use of cognitive computing technologies, which is derived from cognitive science and artificial intelligence, in combination with data generated by connected devices and the actions those devices can perform. Cognitive IoT provides high performance of communicating, computing, controlling, and even high degree of machine intelligence. Cognitive IoT redefines the relationship between human and their pervasive digital environment. They may play the role of assistant or coach for the user. Specifically, the IoT generated big data, when used to power predictive analytics algorithms or to develop a corps for a cognitive computing solution, can provide insights that would never be discovered in time to be useful if the departmental silos do not collaboration in data sensing and analysis. It is the integration of this data that enables cognitive computing applications for IoT of the next decade. Therefore, the services of a cognitive IoT could be constructive, prescriptive, or instructive in nature.

Although IoT has emerged with a great potential to change our life, especially with ubiquitous sensing and sensory data, cognitive IoT technologies will make it possible to understand what is happening in the world more deeply. Therefore, cognitive computing is significant for the IoT to meet many technical challenges and problems that need to be addressed to realize this potential, such as big sensory data generation, computing at the edge of IoT, integration of multiple data sources and types, etc. Furthermore, to address the new computing and communication paradigm, the IoT ecosystems have to be upgraded with new capabilities, such as machine learning, IoT sensing, data analytics, and cognitive power for providing human intelligence.

This JOURNAL's Special Issue (SI) aims to explore recent advances and disseminate state-of-the-art research related to IoT on designing, building, and deploying novel cognitive computing, services and technologies, to enable smart IoT services and applications.

The response to our Calls for Papers on this SI was satisfactory, with 28 submissions from around the globe. During the review process, each paper was assigned to and reviewed by at least three experts in the relevant areas, with a rigorous two-round review process. Thanks to the great support of the Editor-in-Chief of this JOURNAL, Dr. Sherman Shen, we are able to accept 15 excellent papers covering various aspects of cognitive IoT.

In the paper "The Future Internet of Things: Secure, Efficient, and Model-Based," the authors propose a solution modeled on human use of context and cognition, leveraging cloud resources to facilitate IoT on constrained devices units. And it presents an architecture applying process knowledge to provide security through abstraction and privacy through remote data fusion. Specifically, the novel architecture consists of quality of data targets, security and cognitive layers, mathematical-model based data proxies, and an application agent to optimizing sampling costs or minimizing error subject to constraints.

A major challenge in cognitive IoT is the packet transmission efficiency using cognitive networks. To address this challenge, the paper "A New Deep-Q-Learning-Based Transmission Scheduling Mechanism for the Cognitive Internet of Things" proposes a new Q-learning-based transmission scheduling mechanism using deep learning to achieve the appropriate strategy to transmit packets of different buffers through multiple channels to maximize the system throughput.

To recover missing data among the massive sensed data of the IoT, the paper "Probabilistic Recovery of Incomplete Sensed Data in IoT" proposes a probabilistic method based on probabilistic matrix factorization (PMF) to recover missing (incomplete) data from IoT sensors by utilizing data from related sensors. Simulation results show that the proposed PMF model with clustering outperforms support vector machine and deep neural network algorithms in terms of accuracy and root mean square error.

The paper entitled "SRSM-Based Adaptive Relay Selection for D2D Communications" proposes an adaptive relay selection method that exploits the social network and establishes a physical domain and social domain-based model named the social-based D2D relay selection model to address relay selection failure caused by the diversity of users cooperation willingness and the instability of communication links due to human mobility.

In the paper "A Knowledge Fusion Approach for Context Awareness in Vehicular Networks," the authors propose a novel logic-based framework enabling a contextual data management and mining in vehicular ad-hoc networks (VANETs). It grounds on a knowledge fusion algorithm based on nonstandard, nonmonotonic inference services in description logics, adopting standard semantic Web languages. The approach has been implemented in a vehicular network simulator and early experimental results proved its effectiveness and feasibility.

The paper "Materializing the Promises of Cognitive IoT: How Cognitive Buildings Are Shaping the Way" devises a cognitive IoT architecture that integrates thousands of sensors present in our buildings in order to learn the buildings' behavior and intuitively assist users in diagnosing and mitigating undesired events. And it presents the potential of cognitive

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IoT to create highly scalable, adaptable, and interactive IoT systems functioning for buildings and capable of addressing the challenges encountered in the realm of Homes, Smart Cities, and Industry 4.0. In the paper "Analysis of Information Delivery Dynamics in Cognitive Sensor Networks Using Epidemic Models," the authors propose a hybrid interference-aware flooding scheme for cognitive radio ad hoc network that utilizes global timeout and antipackets for information dissemination control. The simulation results show that the implementation of the proposed flooding scheme indeed mitigates the buffer occupancy burden while providing statistical data delivery guarantees. Moreover, with the aid of mobility, information dissemination is shown to possess distinct characteristics that facilitates information dissemination.

For advanced material handling, the authors of the paper "Context-Aware Cloud Robotics for Material Handling in Cognitive Industrial Internet of Things" designs a cognitive industrial entity called context-aware cloud robotics (CACR). Compared with the one-time on-demand delivery, CACR is characterized by two features: 1) context-aware services and 2) effective load balancing. Simulations indicate the superiority of cognitive industrial IoT and show that using CACR for material handling can significantly improve energy efficiency and save cost.

In the paper "People-Centric Cognitive Internet of Things for the Quantitative Analysis of Environmental Exposure," the authors present an architecture for a people-centric and cognitive IoT (PIoT) environmental sensing platform, which involves closed loops of interactions among people nodes and physical devices, as well as servers and recommendations on device connections by cognitive computing. Moreover, a PIoT prototype sensing system is designed and deployed to measure the space–time distribution of particulate matter in air (PM 2.5), and mobility counts, for quantifying personal exposure to air pollution.

The paper "A Microbial Inspired Routing Protocol for VANETs," is a bio-inspired unicast routing protocol for vehicular ad hoc networks, which uses the cellular attractor selection mechanism to select next hops. The proposed unicast routing protocol based on attractor selecting is an opportunistic routing protocol, which is able to change itself adaptively to the complex and dynamic environment by routing feedback packets.

In the paper "Motor Anomaly Detection for Unmanned Aerial Vehicles Using Reinforcement Learning," the authors propose a reinforcement learning-based anomaly detection system to prevent the motor of the unmanned aerial vehicles from operating at abnormal temperatures. The experimental results confirmed that the proposed system can safely control the drone using information obtained from temperature sensors attached to the motor.

Considering emotional care, especially for children, elderly, and mentally ill people, the authors of the paper "Emotion-Aware Connected Healthcare Big Data Towards 5G" propose an emotion-aware connected healthcare system using a powerful emotion detection module to capture speech and image signals of a patient in a smart home scenario. It verifies that the proposed framework would greatly contribute personalized and seamless emotion-aware healthcare services toward 5G.

The paper "Narrow Band Internet of Things: Simulation and Modeling" present the narrowband IoT (NB-IoT) development, and main characteristics and design objectives of NB-IoT according to 3GPP R13. The simulation results have verified the performance of NB-IoT, wherein uplink time delay is lower than 10 s, channel utilization is higher than that of Long Term Evolution (LTE) network, and coverage area is larger than LTE network.

The authors of paper "Fusion of Nonintrusive Environmental Sensors for Occupancy Detection in Smart Homes" present an approach to detect and count occupants using a fusion of environmental sensors from an indoor air quality measurement system. Furthermore, a method is proposed to greatly reduce time and effort of collecting training data in residential buildings. The results indicated that the predictive power of volatile organic compound sensing is comparable to that of carbon dioxide. With a simple naïve Bayes classifier, the approach detected occupancy and estimated the number of occupants with an accuracy of 81.1% and 64.7%, respectively.

To improve the cognitive ability of IoT, the authors of the paper "Device Clustering Algorithm Based on Multimodal Data Correlation in Cognitive Internet of Things" design a device level multimodal data correlation mining model to transform the data feature into a subspace and analyze the data correlation. Extensive simulations are carried out and show that the proposed scheme can effectively improve the quality of data transmission and the intelligent service.

We express our gratitude to the authors for their excellent contributions to this SI. We are also thankful for all reviewers dedicating their efforts in reviewing these papers, and for their valuable comments and suggestions that significantly improve the quality of them. We hope that this SI will serve as a good reference for researchers, scientists, engineers, and academicians in the field of cognitive IoT.

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