

EDITORIAL**IEEE ACCESS SPECIAL SECTION EDITORIAL:
INNOVATION AND APPLICATION OF INTERNET
OF THINGS AND EMERGING TECHNOLOGIES
IN SMART SENSING**

The Internet of Things (IoT) technology is not just about the connection among billions of devices but also about enabling a wide range of new capabilities, architectures, or service paradigms. The scale of the IoT is set to have a major economic, social, and environmental impact. However, the implementation of IoT faces various challenges, including sensing ability, energy consumption, power supply, data security, privacy, and data accountability. In order to mitigate these challenges, more and more IoT systems are embracing the new IoT paradigm, such as millimeter-wave (mmWave), sensor-less sensing, backscattering Wi-Fi/RFID, wireless/vision hybrid, blockchain, fat client, and so on. These modes shed light on the emerging technologies that could revolutionize the conventional IoT systems.

This Special Section accepted high-quality submissions from open calls and invitations. A summary of these articles is outlined below.

In the article entitled “Improvement of detection and localization performance using the receiving array response difference between ocean noise and signal in shallow water,” by Zhang *et al.*, the authors study the receiving array response of an SVLA in shallow water to a distant sound source. Using the normal mode method, they analyze the response by theoretical derivation.

In the article entitled “Analysis of the effect of the reliability of the NB-IoT network on the intelligent system,” by Jia *et al.*, the authors deeply evaluate the impact of the NB-IoT network on the reliability of IoT intelligent systems. They simulate a real-world scenario by using the NS-3 simulator, then carry out several data transmission experiments and record the relevant data of transmission performance indicators, and finally calculate and analyze the reliability results by using quantitative reliability indicators.

In the article entitled “Compressive sensing-based clustering joint annular routing data gathering scheme for wireless sensor networks,” by Yuan *et al.*, the authors propose a compressive sensing-based clustering joint annular routing data gathering (CS-CARDG) scheme to improve network life.

The theoretical analysis results show that the CS-CARDG strategy they proposed can effectively reduce the amount of data carried by nodes.

In the article entitled “Context-aware implicit authentication of smartphone users based on multisensor behavior,” by Wang and Tao, the authors propose a context-aware implicit authentication, which is a scheme to improve the robustness of authentication by introducing a context awareness module. They first capture multisensor data in a fine-grained manner to characterize one’s touch action. Then, they extract gesture features and touch features by employing both the statistical method and distance measurement method.

In the article entitled “On overcoming the identified limitations of a usable PIN entry method,” by Chakraborty *et al.*, the authors propose a few modifications to the famous IOC BW method to regain its high-security standard against all the known forms of observational attacks. They make a critical discussion on the importance of the targeted PIN entry method in the domain of usable security and then give a brief overview of the identified limitations of this protocol. Followed by this, they take a few initiatives to fix the identified vulnerabilities of Roth *et al.*’s proposal by revising its working principle, while the login procedure and the usability standard of this method stay unaffected.

In the article entitled “MCTE: Minimizes task completion time and execution cost to optimize scheduling performance for smart grid cloud,” by Zhang *et al.*, the authors study and analyze the application of heuristic algorithms in cloud task scheduling problems and propose a cloud task scheduling strategy to minimize the task completion time and execution cost (MCTE) for the smart grid cloud. Then, they carry out mathematical modeling on the grid cloud task scheduling problem.

In the article entitled “Career age-aware scientific collaborator recommendation in scholarly big data,” by Sun *et al.*, the authors aim to design a scientific collaboration recommendation model that is sensitive to scholars’ career age. For this purpose, they design a career age-aware scientific

collaboration model. The model mainly consists of three parts, including authorship extraction from digital libraries, topic extraction based on publication titles and abstracts, and career age-aware random walk for measuring scholar similarity.

In the article entitled “Solving optimal camera placement problems in IoT using LH-RPSO,” by Wang *et al.*, the authors handle the continuous camera values in the continuous domain directly to get a much more accurate result of the optimal camera placement problem. Meanwhile, they propose a Latin hypercube-based resampling particle swarm optimization (LH-RPSO) algorithm to effectively solve the problem.

In the article entitled “Unbalanced multistage heat conduction and mass diffusion algorithm in an educational digital library,” by Yin *et al.*, the authors propose a weighted network-based information filtering framework that models user usage as a bipartite user-resource network to achieve the purpose of both precision and diversity while providing online educational resource services. In this network, users and resources are treated as nodes, each edge from a user to a resource means usage, and the weight represents the accumulation of multiple usage scenarios.

In the article entitled “Improved density peak clustering based on information entropy for ancient character images,” by Weng *et al.*, the authors explore the classification method of ancient Chinese character images based on density peak clustering to tackle the challenge in which an ancient character image needs to be manually labeled. They design a metric function of density peak clustering and propose an improved density peak clustering method based on information entropy for ancient book image classification.

In the article entitled “A request-transmission splitting scheme for V2X networks: Design and throughput analysis,” by Peng *et al.*, the authors propose a request-transmission splitting slotted ALOHA-based scheme, referred to as the RTS-SA, to improve the access capacity for V2X networks in which a frame is divided into three phases. The first phase is short and utilized by vehicles when competitively transmitting their identities to roadside units (RSUs) for accessing requests in a coded manner. Then, RSUs implement multiuser detection and decoding simultaneously and act as the coordinator to broadcast the allocated time slots for the vehicles to guarantee contention-free transmission in the third phase.

In the article entitled “Vehicle ego-localization based on the fusion of optical flow and feature points matching,” by Xin *et al.*, the authors propose a vehicle ego-localization method based on the fusion of optical flow and feature points matching to meet the requirement of the vehicle in real-time and precise ego-localization on flat city roads. Their study can achieve higher positioning accuracy in real-time and has a better result for ego-localization on flat pavement.

In the article entitled “Model aggregation method for data parallelism in distributed real-time machine learning of smart sensing equipment,” by Fan *et al.*, the authors develop a loss

function weight reorder stochastic gradient descent method (LR-SGD) due to the loss of accuracy caused by the direct averaging of the parameter average method. They use the loss function value to determine the weight of the work nodes when aggregating the model parameters. This method improves the performance of the parameter average method for nonconvex problems.

In the article entitled “Memory leak detection in IoT program based on an abstract memory model SeqMM,” by Dong *et al.*, the authors propose an abstract memory model SeqMM to describe sequential storage structures to improve the precision of memory leak detection. Their method has ability to handle both points-to analysis and numerical analysis of pointers, which contributes to eliminating false positives in defect detection.

In the article entitled “Cryptanalysis and improvement of an anonymous batch verification scheme for mobile health-care crowd sensing,” by Wang *et al.*, the authors present an improved anonymous scheme based on certificateless aggregate signature (CL-AS) for MHCS. First, they adopt the technique of aggregate signature, which can achieve batch verification and greatly save bandwidth and computation resources. Second, they carry out anonymous communication in this scheme to realize privacy preservation. Third, their scheme can simplify complicated certificate management and eliminate the key escrow problem.

In the article entitled “Server consolidation energy-saving algorithm based on resource reservation and resource allocation strategy,” by Song *et al.*, the authors apply resource reservation to the resource-utilization-aware energy efficient server consolidation algorithm (RUAEE) and propose a server consolidation energy-saving algorithm (SCES). They adjust the allocations of VMs by computing the resource reservation and resource allocation ratio dynamically. This technique maintains the host resource utilization within a reasonable range, reduces resource fragmentation, and reserves resources to satisfy the peak resource requests simultaneously.

In the article entitled “Research on intelligent monitoring and analysis of physical fitness based on the Internet of Things,” by Huang *et al.*, the authors design an intelligent physical fitness monitoring system based on the IoT technology to meet the current demand for smartphone popularization and athlete training monitoring. They select some factors, use RFID technology to mark different athletes, and establish the evaluation model of the athletes’ physical condition after using the particle swarm optimization method of the back-propagation (BP) network.

In the article entitled “An intelligent communication warning vulnerability detection algorithm based on IoT technology,” by Yi *et al.*, the authors mainly study the vulnerability of intelligent early warning technology in the IoT environment, study the network security assessment method based on the attack graph association analysis of the IoT environment, and analyze the attack graph generation algorithm. First, they use the attack graph technology to establish a

network security evaluation model based on the vulnerability association analysis. Second, they propose an intelligent early warning vulnerability detection algorithm based on the dynamic strain propagation model in the IoT environment.

In the article entitled “Dispatch for urban-integrated heat and power system considering secondary PM2.5 under smart environmental sensing,” by Peng *et al.*, the authors propose a stochastic environmental economic dispatch (SEED) model for urban-integrated heat and power systems (UIHPS) considering integrated demand response (IDR), and introduce linearized secondary PM2.5 generation and diffusion functions for UIHPS dispatch into the objective function. They perform the price-based IDR on the Stackelberg game mechanism and transform the game equilibrium solution as the SEED’s constraint set using the backward induction method.

In the article entitled “Energy analysis and application of data mining algorithms for Internet of Things based on Hadoop cloud platform,” by Zheng and Chen, the authors analyze and study the classification and characteristics of the Internet of Things (IoT) information, and discuss the construction and application of Hadoop cloud platform. They mainly carry out the work from two aspects. One is to design the system architecture of the open platform for data simulation resources of the IoT and design the key modules. The other is the key method to study the simulation data model based on IoT sensors.

In the article entitled “Near-optimal user recruitment in mobile crowdsensing for urban fine-grained event detection,” by Liu *et al.*, the authors propose a polynomial-time near-optimal user recruitment algorithm to address the user recruitment problem in mobile crowdsensing for event detection by leveraging the properties of adaptive monotonicity and adaptive submodularity. Moreover, they derive a data-dependent upper bound to provide a tighter performance guarantee. They also provide an accelerated version of the algorithm by reducing its computation load.

In the article entitled “Central prediction system for time series comparison and analysis of water usage data,” by Ji *et al.*, the authors develop a system that can generate automatic alarms whenever abnormal usage is predicted via analysis of household water flow rate. They find the best method with high accuracy by comparing linear regression, ARIMA model, and additive regression model. Their method can support efficient water system management to lower the nonrevenue water (NRW) ratio.

In the article entitled “Enabling ordinary users mobile development with Web components,” by Wang *et al.*, the authors take consideration of ordinary users’ requirements and propose a what-you-see-is-what-you-get (WYSIWYG) cross-platform web-component-based mobile application creation environment for ordinary users, instead of traditional programming environments. The proposed solution can help ordinary users generate installing packages within simple operations for multiple platforms.

In the article entitled “UCAA: User-centric user association and resource allocation in fog computing networks,” by Tong *et al.*, the authors aim to maximize the user experience and overall system performance by jointly optimizing user association and resource allocation in the scenarios mentioned, which can be formulated as a mix-integer nonlinear programming problem. To solve the NP-hard problem, they propose a low-complexity two-step interactive optimal algorithm, namely the UCAA algorithm.

In the article entitled “An Internet of Things roaming authentication protocol based on heterogeneous fusion mechanism,” by Wan *et al.*, the authors design an IoT node roaming authentication model, which is used to enhance the security authentication capability of the IoT to roaming devices. After that, they propose a roaming authentication protocol based on a heterogeneous fusion mechanism (HFM-IoT) to effectively prevent malicious nodes from connecting to the network.

In the article entitled “FairEdge: A fairness-oriented task offloading scheme for IoT applications in mobile cloudlet networks,” by Lai *et al.*, the authors propose “FairEdge,” a fairness-oriented computation offloading scheme to enable balanced task distribution for mobile edge cloudlet networks. By integrating the balls-and-bins theory with fairness index, their solution promotes effective load balancing with limited information at low computation cost.

In the article entitled “Towards recommendation in Internet of Things: An uncertainty perspective,” by Liu *et al.*, the authors propose a new recommender framework with item dithering to solve the data uncertainty problem in IoT-based recommender systems. Based on the proposed framework, they also design IDither, item-based dithering, and recommendation algorithm to shake out irrelevant items through predetermined indicators, thereby retaining the items required by the user and recommending them to the user.

In the article entitled “Improvement of ancient Shui character recognition model based on convolutional neural network,” by Zhao *et al.*, the authors use deep learning theory into character recognition technology for Shui characters in ancient books, with the objectives of overcoming the instability of the high-pixel ancient Shui characters generative model and the need for large-scale handwritten text data annotation among other issues. They use the feedback from the convolutional neural network to determine the algorithmic model of the hyperparameters for clustering annotation. This structure is also designed to improve the recognition rate of handwritten Shui characters in ancient books.

In the article entitled “A smart UAV-femtocell data sensing system for post-earthquake localization of people,” by Avanzato and Beritelli, the authors propose an intelligent data sensing and geo-localization algorithm, based on an innovative mobile computing system that measures the power level of RF sources through a 2G/5G femtocell-UAV system. In natural disasters (mainly earthquakes and floods), the

system can identify any missing persons under the rubble within a range of precision between 1 m and 2 m.

In the article entitled “Defect diagnosis of disconnect based on wireless communication and support vector machine,” by Zhou *et al.*, the authors propose a wireless monitoring method for the mechanical state of disconnectors to address the shortage of mechanical defect detection and diagnosis technology for disconnectors. Their wireless monitoring method can effectively diagnose the mechanical state of the disconnector and has a good generalization ability.

In the article entitled “A scheme of intelligent traffic light system based on distributed security architecture of blockchain technology,” by Zeng *et al.*, the authors propose a distributed security architecture scheme based on blockchain technology for the existing intelligent traffic light system based on its outstanding characteristics in the distributed architecture and the development of edge intelligence (EI) technology. At the same time, they also improve the smart contract to achieve redundant cutting of ledger data in the process of block consensus, which greatly reduces the pressure of blockchain ledger data transmission.

In the article entitled “Copy-move forgery detection based on keypoint clustering and similar neighborhood search algorithm,” by Chen *et al.*, the authors propose an efficient copy-move forgery detection (CMFD) method via clustering SIFT keypoints and searching similar neighborhoods to locate tampered regions. In this method, the keypoints are clustered based on scale and color, grouped into several smaller clusters, and matched separately, which reduces the high time complexity caused in matching caused by the high dimensionality of SIFT.

In the article entitled “Surface refractivity profile construction on one-fourth kilometer square area for 1800–1900 MHz frequency,” by Hussain *et al.*, the authors study the variation in radio refractivity for frequency of 1800–1900 MHz at different locations. Through the Atoll software, they analyze transmission coverage for the investigated area. They measure both reference signal received power (RSRP) and reference signal received quality (RSRQ) which show a better result in the considered territory. After that, they establish an experimental setup in the same locations of the investigated area.

In the article entitled “The connectivity evaluation among wells in reservoir utilizing machine learning methods,” by Du *et al.*, the authors propose an alternative way for evaluating the interwell connectivity in oil fields utilizing machine learning. They utilize a 3-D convolutional neural network (CNN) to establish a deep learning model, which can invert interwell connectivity combining with dynamic production data. At the same time, they build the backpropagation (BP) neural network to analyze the prediction performance, which is compared with CNN.

In the article entitled “Toward industrial ultra-wideband networks: Experiments for machine vibration monitoring,” by Schmidt *et al.*, the authors discuss the potential of

ultra-wideband (UWB) technology for realizing use cases in industry 4.0 and demonstrate the implementation of a UWB sensor network with off-the-shelf transceivers for machine vibration monitoring. They propose a flexible medium access layer tailored for industrial sensing and show how the choice of its parameters is affected by the propagation environment and hardware constraints.

In the article entitled “KNN-based approximate outlier detection algorithm over IoT streaming data,” by Zhu *et al.*, the authors propose a novel framework named GAAOD (grid-based approximate average outlier detection) to support kNN-based outlier detection over IoT streaming data. First, they introduce a grid-based index to manage summary information on streaming data. Second, they use a min-heap-based algorithm to compute the distance upper/lower bound between objects and their k th nearest neighbors, respectively. Third, they utilize a k -skyband-based algorithm to maintain outliers and candidate outliers.

In the article entitled “Challenges and opportunities of the Internet of Things for global development to achieve the United Nations sustainable development goals,” by López-Vargas *et al.*, the authors study the current context to successfully apply the IoT in developing countries to achieve the sustainable development goals (SDGs) of the United Nations. They review the potential and opportunities of the IoT in the developing world as well as the current challenges of the IoT in developing countries.

In the article entitled “System assessment of WUSN using NB-IoT UAV-aided networks in potato crops,” by Castellanos *et al.*, the authors propose a narrow band IoT (NB-IoT) system for collecting underground soil parameters in potato crops using a UAV-aided network. To this end, they develop a simulation tool implementing a gateway mounted on a UAV using NB-IoT-based access network and LTE-based backhaul network.

In the article entitled “S2N2: An interpretive semantic structure attention neural network for trajectory classification,” by Jin *et al.*, the authors propose a novel scenario-based deep learning method which is based on the assumption that people visit places with explicit purposes. They first represent semantic patterns from daily life, create various scenarios, and utilize an attention neural network to embed points of trajectories by considering both semantic and geographical information. Then, they construct a semantic structure neural network (S2N2) framework to perform the end-end classification.

In the article entitled “Toward imbalanced image classification: A generative adversarial network ensemble learning method,” by Huang *et al.*, the authors propose a new ensemble framework based on the advanced generative adversarial network and an effective data cleaning way to address the class imbalance problem for weather classification. Their method not only generates new and reliable samples for the minority class to restore balance but also filters those generated samples which are unreliable.

In the article entitled “Dynamic priority-based efficient resource allocation and computing framework for vehicular multimedia cloud computing,” by Siddiqi *et al.*, the authors propose an efficient resource allocation and computation framework for vehicular multimedia cloud computing to overcome the challenges related to multimedia contents processing, (i.e., resource cost, fast service response time, and quality of experience) that severely affect the performance of vehicular communication.

The Guest Editors would like to express their deep gratitude to all the authors who submitted their valuable contributions, and to the numerous and highly qualified anonymous reviewers. They think that the selected contributions, which represent the current state of the art in the field, will be of great interest to the community. They also would like to thank the IEEE ACCESS publication staff members for their continuous support and dedication. They particularly appreciate the support and encouragement granted to them by Dr. Derek Abbott, the Editor-in-Chief of IEEE ACCESS.

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