JOURNAL OF INFORMATION PROCESSING SYSTEMS JIPS

IoT and Smart City Technology: Challenges, Opportunities, and Solutions

Young-Sik Jeong* and Jong Hyuk Park**

Abstract
Internet of Things (IoT) technology has been recently utilized in diverse fields. Smart city is one of the IoT application domains with a lot of research topics and which is operated by integrated IoT applications. In this paper, diverse kinds of solutions, processes, and frameworks to address the existing challenges in information technology are introduced. Such solutions involve various future track topics including blockchain, security, steganography, optimization, machine learning, smart system, and so on. In the subsequent paragraphs, we describe each topic in a summarized way in terms of the existing challenges and their solutions. Specifically, this paper introduced 18 novel and enhanced research studies from different countries in the world. We present diverse kinds of paradigms to subjects that tackle diverse kinds of research areas such as IoT and Smart City, and so on.

Keywords
Internet of Things, Smart City

1. Introduction

Smart city based on Internet of Things (IoT) technology is one of the key research topics. Especially, smart city applications require diverse kinds of integrated algorithms such as IoT, security, software architecture, artificial intelligence (AI), image processing, and so on, which enable various smart city applications. For example, AI algorithms are utilized for autonomously controlling devices such as buildings, vehicles, and so on. Security algorithms are utilized for managing the data invoked by smart city applications. Software architectures are required to integrate the huge size of IoT applications.

Since diverse kinds of algorithms are integrated and utilized for smart city applications, there is a need to investigate the integrated algorithms in the smart city applications. This paper introduces 18 novel and enhanced research studies. We present diverse kinds of paradigms to subjects that tackle diverse kinds of research areas such as IoT and Smart City, and so on. Especially, futuristic, hot-issue topics from the academe and industries are described. The main purpose of the paper is to provide hot and trendy research to researchers quickly.

This paper consists of two sections: introduction and IoT and Smart City research. Smart City research

in Section 2 introduces 18 high-quality papers. In particular, these included papers mainly focus on various perspectives IoT, smart system, security, optimized resources, block chain, and so on, which tackle diverse kinds of research areas such as IoT and Smart City, and so on.

2. IoT and Smart City Research

Addressing the weaknesses found in the cloud environment to maintain the data integrity of e-health systems, Kubendiran et al. [1] proposed a framework implementing the blockchain technology to fulfill the requirements for stable and secure technology. They also introduced an algorithm based on a new partition-based device discovery scheme to establish data provenance. Compared to other existing methods, the proposed method exhibited shorter data discovery time.

Ensuring that consensus is actualized quickly by second-order multi-agent systems (MAS), Chen et al. [2] proposed a new protocol with the inclusion of the gradient algorithm of the overall cost function in the existing original protocol. The suggested protocol was directed at improving the connection among neighboring agents and the moving speed amid the agents. The simulation results showed improvements in the system in terms of stability, increased robustness, and faster convergence compared to other protocols.

Halder et al. [3] proposed steganography protocols to safeguard secret digital documents against any unauthorized access by hiding the entire content. The approach includes a block-wise embedding process of blocks of varying sizes chosen from the cover image. To minimize the error rate, the optimal pixel adjustment process is implemented. Compared to existing methods, the proposed protocol has superior hiding capacity and improved signal to noise ratio.

Zhang and Han [4] proposed an audio watermarking scheme with improvements in terms of endurance against desynchronization attacks, audibility, and increased imperceptibility of the scheme over the original scheme for robust audio watermarking. The test results indicate that the proposed scheme maintains high audio quality, resistance to attacks such as additive white Gaussian noise, resampling, compression, and jitter and has low false alarm rate and better search efficiency.

Haridoss and Punniyakodi [5] suggested the implementation of opposition-based improved harmony search algorithm in histogram-based multilevel thresholding for the compression of medical MRI and CT images. The proposed concept addresses the problem of loss of preservation of original content and development of artefacts at high compression ratio. The proper selection of entropy combined with the number of thresholds selected in the reconstruction of the compressed images maintains the important information present in the images.

Addressing the need for the accurate prediction of the total count of containers for container transport in foreign trade, Ding et al. [6] proposed the use of grey relational analysis for a precise forecast index system. The prediction model was built using a combination of back-propagation neural networks and support vector machines for superior accuracy compared to existing methods. The test results show maximum error rate of 1.5%, illustrating minimum accurate prediction of 98.5%.

Kang [7] analyzed the changes in the sociality and democratic citizenship of elementary school students in two different classes. The class is divided into two groups: one led by a general instructor, and the other using the Learning Together cooperative form of learning supported with the application of the experimental educational programming language, a remix function of Scratch. Results showed a

cooperative community spirit and a sense of responsibility in the experimental group.

Zhou et al. [8] presented a measurement uncertainty analysis based on the Monte Carlo method to study the dynamic thermal rating of the overhead transmission lines. The mathematical calculation results obtained show that the dynamic thermal rating exhibits the current carrying capacity of the overhead transmission line. The model calculation demonstrates that the temperature distribution of the transmission line under varying current carrying conditions can be realized. The proposed study also analyzes the risk of line operation under different circumstances.

Surveillance cameras are essential for recording events for security and safety purposes, but observing and analyzing incidents can be a tedious task. Yu and Lee [9] proposed the use of the SURF method combined with the background subtraction method. The combination of both techniques resolves the unexpected tracking errors encountered by the SURF algorithm when used alone and increases the tracking accuracy. The background subtraction algorithm can identify people in videos, whereas SURF supports the tracking of targets. The proposed algorithm can detect the entry and exit of a person automatically.

Liu et al. [10] proposed two incremental fuzzy compactness and separation clustering (FCS) algorithms, single-pass and online FCS, to enable storage of large-scale clustered datasets within limited memory. The proposed methods are first combined separately with the weighted fuzzy C-means algorithm, and then applied to the FCS algorithm. The proposed algorithm experiments on artificial and real datasets show that they are more robust for the fuzzy index m value and noise than the existing methods.

Nguyen et al. [11] employed finite impulse response (FIR) filter banks to implement an optimal Daubechies-based pipelined discrete wavelet packet transform (DWPT) processor. The proposed DWPT supports effective transposing from a structure that leads to a 50% reduction in the time complexity of the system. The convolution of FIR filter banks is optimized by introducing the AFS technique. The proposed design was experimentally evaluated using an intellectual property (IP) logic core that demonstrated the efficiency of DWPT in terms of hardware resource utilization with acceptable accuracy.

Sun et al. [12] discussed the effect of environmental parameters on the transmission capacity of the transmission line. They introduced a mechanism for estimating the environmental parameters for ordinary Kriging interpolation and inverse distance weighted interpolation. The proposed mechanism was realized and tested over a Chinese metrological data network. The testing results demonstrated that the proposed mechanism improves the accuracy of the dynamic rating and reduces the cost of the environmental measurement device.

Nguyen et al. [13] addressed the challenges of reconstruction of 3D human pose from a single-view image and proposed an innovative spatial-temporal 3D human pose reconstruction framework to process the 3D human pose reconstruction efficiently. The proposed framework relies on inter- and intra-frame relationships in the context of the sequence of the 2D pose. The proposed framework was evaluated and compared with recent works by employing it over the dataset of CMU motion capture. The evaluation results demonstrated that the proposed framework is robust over Gaussian noise, and that it lowers the Euclidean reconstruction error.

Chen et al. [14] discussed the sparse signals issue in distributed compressed sensing (DCS) and gave an example of block-sparse structures to explain the issue. They proposed a backtracking-based adaptive orthogonal matching paradigm for block DCS (DCSBBAOMP) to mitigate the existing challenges in DCS. The proposed paradigm considers multi-channel signal reconstruction instead of single-channel

signal reconstruction in the existing block methods. Each iteration of the proposed paradigm involves forward selection and backward removal stages to solve the sparse signals issue. The experimental evaluation of the proposed paradigm demonstrated that it achieved acceptable performance.

To enhance the classification performance of a power quality disturbance, Zhao and Gai [15] introduced a novel hybrid kernel function for the support vector machine. According to them, the classification performance is directly affected by the mathematical model of the kernel function in the support vector machine. Learning and generalization abilities vary according to the different kinds of kernel functions. Along with this statement, the authors introduced a hybrid kernel function by combining two single kernel functions of learning and generalization abilities. The proposed work was experimentally tested over single- and multiple-power quality disturbances, showing that it obtained better performance compared to that of other support vector machines.

Huang et al. [16] studied the artificial bee colony (ABC) algorithm that adopts scouts, onlooker bees, and employed bees to support first-rate exploration ability. The study pointed out the issue of slow convergence speed due to greedy search and one-dimension strategy. To overcome this issue, the author introduced an artificial bee colony algorithm with special division and intellective search (ABCIS). The proposed methods adopt different search strategies according to different employed bees and onlooker bees for higher efficiency of food source research. The proposed method was simulated to demonstrate its effectiveness.

Choi and Ahn [17] discussed the issue of cloud computing in smart cities to support the necessity of stringent timing. To overcome this issue, they suggested fog computing paradigm, wherein the placement of fog nodes is performed close to the IoT devices. The authors proposed a fog service placement strategy that supports various requirements, such as storage, CPU, and delay. Fog service placement is presented in a large-scale smart city to demonstrate the effectiveness of the fog network in terms of scalability. A logical fog network methodology was followed to provide service placement in the smart city.

Park et al. [18] introduced a SMART home framework for common household applications in the IoT Network. The SMART home is one of the most popular applications of IoT technologies, and the SMART home framework is called an S-mote; it operates all IoT functions in a single application by adding infrared or radio frequency module to general home appliances.

References

[1] M. Kubendiran, S. Singh, and A. K. Sangaiah, "Enhanced security framework for e-health systems using blockchain," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 239-250, 2019. https://doi.org/10.3745/JIPS.04.0106

[2] L. Chen, Y. Zhang, Y. Li, and L. Xia, "Research on finite-time consensus of multi-agent systems," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 251-260, 2019. https://doi.org/10.3745/JIPS.01.0039

[3] T. Halder, S. Karforma, and R. Mandal, "A block-based adaptive data hiding approach using pixel value difference and LSB substitution to secure e-governance documents," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 261-270, 2019. https://doi.org/10.3745/JIPS.03.0111

[4] J. Zhang and B. Han, "A synchronization scheme based on moving average for robust audio watermarking," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 271-287, 2019. https://doi.org/10.3745/JIPS.03.0112

[5] R. Haridoss and S. Punniyakodi, "Compression and enhancement of medical images using opposition based harmony search algorithm," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 288-304, 2019. https://doi.org/10.3745/JIPS.02.0108

[6] M. J. Ding, S. Z. Zhang, H. D. Zhong, Y. H. Wu, and L. B. Zhang, "A prediction model of the sum of container based on combined BP neural network and SVM," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 305-319, 2019. https://doi.org/10.3745/JIPS.04.0107

[7] O. H. Kang, "Analysis of the sociality and democratic-citizenship changes from the application of the Scratch remix function in cooperative learning," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 320-330, 2019. https://doi.org/10.3745/JIPS.04.0108

[8] X. Zhou, Y. Wang, X. Zhou, W. Tao, Z. Niu, and A. Qu, "Uncertainty analysis of dynamic thermal rating of overhead transmission line," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 331-343, 2019. https://doi.org/10.3745/JIPS.04.0109

[9] J. Yu and K. M. Lee, "Multi-person tracking using SURF and background subtraction for surveillance," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 344-358, 2019. https://doi.org/10.3745/JIPS.02.0109

[10] Y. Liu, H. Wang, T. Duan, J. Chen, and H. Chao, "Incremental fuzzy clustering based on a fuzzy scatter matrix," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 359-373, 2019. https://doi.org/10.3745/JIPS.01.0040

[11] H. N. Nguyen, C. H. Kim, and J. M. Kim, "Optimization of pipelined discrete wavelet packet transform based on an efficient transpose form and an advanced functional sharing technique," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 374-385, 2019. https://doi.org/10.3745/JIPS.01.0041

[12] Z. Sun, Z. Yan, L. Liang, R. Wei, and W. Wang, "Dynamic thermal rating of transmission line based on environmental parameter estimation," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 386-398, 2019. https://doi.org/10.3745/JIPS.04.0110

[13] X. T. Nguyen, T. D. Ngo, and T. H. Le, "A spatial-temporal Three-Dimensional human pose reconstruction framework," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 399-409, 2019. https://doi.org/10.3745/JIPS.02.0110

[14] X. Chen, Y. Zhang, and R. Qi, "Block sparse signals recovery algorithm for distributed compressed sensing reconstruction," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 410-421, 2019. https://doi.org/10.3745/JIPS.04.0111

[15] L. Zhao and M. Gai, "Power quality disturbances identification method based on novel hybrid kernel function," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 422-432, 2019. https://doi.org/10.3745/JIPS.04.0112

[16] H. Huang, M. Zhu, and J. Wang, "An improved artificial bee colony algorithm based on special division and intellective search," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 433-439, 2019. https://doi.org/10.3745/JIPS.02.0111

[17] J. Choi and S. Ahn, "Scalable service placement in the fog computing environment for the IoT-based Smart City," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 440-448, 2019. https://doi.org/10.3745/JIPS.03.0113

[18] D. M. Park, S. K. Kim, and Y. S. Seo, "S-mote: SMART home framework for common household appliances in IoT network," *Journal of Information Processing Systems*, vol. 15, no. 2, pp. 449-456, 2019. https://doi.org/10.3745/JIPS.03.0114

Young-Sik Jeong https://orcid.org/0000-0002-7421-1105

He received his B.S. degree in Mathematics and his M.S. and Ph.D. degrees in Computer Science and Engineering from Korea University in Seoul, Korea in 1987, 1989, and 1993, respectively. Professor Jeong works in the Department of Multimedia Engineering of Dongguk University, Korea. His research interests include multimedia cloud computing, information security for cloud computing, mobile computing, the Internet of Things (IoT), and wireless sensor network applications. He was a professor

in the Department of Computer Engineering of Wonkwang University, Korea, from 1993 to 2012. He worked and conducted research at Michigan State University and Wayne State University as his capacity as a visiting professor in 1997 and 2004, respectively. He is also an executive editor of the *Journal of Information Processing Systems*, an associate editor of the *Journal of Supercomputing* (JoS) and the *International Journal of Communication Systems* (IJCS), an editor of the *Journal of Internet Technology* (JIT), and, finally an associate editor of the *Journal of Human-centric Computing* (HCIS). In addition, he has been employed as a guest editor for various international journals by a number of publishers including Springer, Elsevier, John Wiley, Oxford University Press, Hindawi, Emerald, and Inderscience. He is also a member of the IEEE.

James J. (Jong Hyuk) Park https://orcid.org/0000-0003-1831-0309

He received Ph.D. degrees from the Graduate School of Information Security, Korea University, Korea and the Graduate School of Human Sciences of Waseda University, Japan. Dr. Park served as a research scientist at the R&D Institute, Hanwha S&C Co. Ltd., Korea from December 2002 to July 2007, and as a professor at the Department of Computer Science and Engineering, Kyungnam University, Korea from September 2007 to August 2009. He is currently employed as a professor at the Department of Computer Science and Engineering and the Department of Interdisciplinary Bio IT Materials, Seoul National University of Science and Technology (SeoulTech), Korea. Dr. Park has published about 200 research papers in international journals and conferences. He has also served as the chair, program committee chair or organizing committee chair at many international conferences and workshops. He is a founding steering chair of various international conferences including MUE, FutureTech, CSA, UCAWSN, etc. He is employed as editor-in-chief of *Human-centric Computing and Information Sciences* (HCIS) by Springer, *The Journal of Information Processing Systems* (JIPS) by KIPS, and the *Journal of Convergence* (JoC) by KIPS CSWRG. He is also the associate editor or editor of fourteen international journals, including eight journals indexed by SCI(E). In addition, he has been employed as a guest editor for various international journals by such publishers as Springer, Elsevier, Wiley, Oxford University Press, Hindawi, Emerald, and Inderscience. Dr. Park's research interests include security and digital forensics, human-centric ubiquitous computing, context awareness, and multimedia services. He has received "best paper" awards from the ISA-08 and ITCS-11 conferences and "outstanding leadership" awards from IEEE HPCC-09, ICA3PP-10, IEE ISPA-11, and PDCAT-11. Furthermore, he received an "outstanding research" award from SeoulTech in 2014. Also, Dr. Park's research interests include human-centric ubiquitous computing, vehicular cloud computing, information security, digital forensics, secure communications, multimedia computing, etc. He is a member of the IEEE, IEEE Computer Society, KIPS, and KMMS.