

## Special issue on smart cities and its applications

Smart cities are integrated with information and communication technologies (ICTs) to improve both the quality of public services and the welfare of citizens in the world including South Korea [1]. The smart city migrated into the digital cyber-enabled world with the integration of ICTs, including various city services such as energy, surveillance, transportation, commerce, and so forth [2]. The cyber-enabled world can be better prepared to interact with its citizens and create multiple business opportunities for smart cities in the context of a virtual environment [3].

To better support growing urbanization, the cyber-enabled world can increase operational efficiency and share information about city decisions, processes, and infrastructure by realizing vertical markets. A vertical market represents an urban economy by selling products or services in which a specific industry or group of companies use similar means for development. For example, insurance, real estate, banking, home sharing, and heavy industry could refer to vertical markets. Vertical markets reduce costs and resource consumption from an economic viewpoint while combining the new generation of information technology, such as the Internet of Things (IoT) and cloud computing [4]. In fact, smart-city construction can bring transformation to the global economic development model and advance the market structure.

The evolution and rapid deployment of vertical markets generates massive amounts of data at an unprecedented rate. Unfortunately, most data are wasted without exploiting potential knowledge because no mechanism to extract useful information exists. Additionally, the highly dynamic nature of urban life requires flexible and adaptable approaches that can cope with the dynamics of data to perform analytics and learn from real-time data. With emerging cyber-intelligence technologies, including big data, machine learning (ML), and artificial intelligence (AI), vertical markets move us closer to developing new smart-city applications that deliver complete adaptive data management solutions [5]. Smart-city applications can learn environment change conditions from a wide set of data, gain experience in context supported by big data

analytics, and perform autonomic actions without human intervention.

Here, we highlight several challenges, as well as promising future research directions, for incorporating ML and high-level intelligence into smart cities and their applications. When we think about a smart city and its applications, we consider how city resources are managed through cyber-intelligence technologies. Development of smart-city applications must address concerns for optimal provisioning and efficient utilization of city resources. In addition, providing smart-city applications for transportation, healthcare, convenience, agriculture, and government are the main premises of a smart city.

*Electronics and Telecommunications Research Institute (ETRI) Journal* is a peer-reviewed open access journal launched in 1993 and published bimonthly by ETRI, Republic of Korea, aiming to promote worldwide academic exchange in the field of information, telecommunications, and electronics. The objective of this special issue is to focus on all aspects and future research directions in the rapidly progressing subject of smart cities and their applications. In particular, this special issue is dedicated to highlighting recent outstanding results for adopting cyber-intelligence and cognitive computing technologies in smart cities and their applications. We received a total of 15 manuscripts worldwide for this special issue and, after a rigorous review process, only 6 manuscripts have been published in this special issue. A short review regarding commitments for this special issue follow.

Smart cities use a variety of IoT technologies and databases to improve efficiency and efficacy of city services. One of the main research areas in smart cities is how to combine and utilize data collected from various smart agents, such as surveillance cameras. The first paper [6] “Multimodal layer surveillance map based on anomaly detection using multi-agents for smart city security” by Shin and others deals with anomaly detection for both human behaviors and vehicle maneuvers, which lead to higher security in city life. This paper utilized a surveillance map database to train and test a model to detect anomalies. The proposed model showed good

performance and the authors confirmed that the model is promising for operating and managing smart cities.

Cities are constantly innovating with the help of AI. Use of AI technologies within smart cities will allow these cities to be smarter. From this point of view, reinforcement learning (RL)-based intelligent transportation systems (ITSs) to reduce traffic congestion in smart transportation systems have been studied by many researchers. The second paper in this special issue, [7] “Exploring Reward Efficacy in Traffic Management using Deep Reinforcement Learning in Intelligent Transportation System” by Paul and Mitra, shows that by integrating traffic signals with the IoT, the power of edge computing can be harnessed in designing an effective adaptive traffic signal control system to alleviate traffic congestion without incurring considerable costs. In particular, this problem is difficult to solve in large-scale complex environments. The authors achieved this by specifying several deep neural network (DNN) frameworks with a well-designed multi-objective reward function, which is advantageous as it simultaneously optimizes many-parameter values for a faster learning process.

Another issue that can be improved using AI techniques in smart cities is crime prediction and prevention. The third paper in this special issue, [8] “Crime amount prediction based on 2D convolution and long short-term memory neural network” by Dong and others, adopted state-of-the-art deep learning models when forecasting regional crime levels. The authors identified spatiotemporal dependencies among crime record data by incorporating convolutional and recurrent neural nets, which enhanced the performance of forecasting crime amounts. Extensive experiments on real-world datasets validated the utility of their proposed integrated scheme.

The share-a-ride problem has been spotlighted as an efficient planning model to facilitate the flow of people and goods in smart cities. In this regard, the fourth paper, [9] “Novel Online Routing Algorithms for Smart People-Parcel Taxi Sharing Services” by Nguyen and others, proposed a new people-parcel taxi sharing model that can accommodate more parcel delivery requests, in addition to rider requests, while minimizing taxi idle time and distance. Unlike conventional approaches, the proposed algorithms apply learned information based on historical data analysis of routing with the objectives of maximizing overall travel efficiency and minimizing driver idle time. The rigorous analysis and experimental results demonstrate the effectiveness of the proposed method.

Rapid changes in modern society exhibit a profound impact on cities and their people. Moreover, changes in household composition and residential environment greatly affect the characteristics of postal delivery areas,

increasing the overall workload of domestic postal delivery services. The fifth paper in this special issue, [10] “Understanding Postal Delivery Areas in the Republic of Korea Using Multiple Unsupervised Learning Approaches” by Han and others, investigated the overall workload of postal delivery services using various unsupervised learning approaches in the Republic of Korea. In the study, the authors applied multiple clustering methods, as well as feature engineering, to obtain optimal grouping of postal delivery areas and workload balancing of postal delivery services.

The last paper in this special issue, [11] “Practical method to improve usage efficiency of bike-sharing systems” by Lee and others, explored the bike rebalancing problem in bike-sharing systems. In order to solve the rebalancing problem, the authors designed a bike demand prediction model based on machine learning techniques. The proposed approach was applied to the bike system in Sejong city, Korea, and it showed better performance in terms of accuracy and receiver operating characteristic compared to basic and naïve models.

According to [12], smart cities have been defined in diverse categories, including the following city technological brands: digital city, intelligent city, ubiquitous city, and information city. In addition, a city can get smart not only through cutting-edge technologies but also through collaboration with the people and communities within. Therefore, a wide variety of studies on smart-city systems and services are required. In this special issue, we published only six contributions related to security, transportation, and the postal system. Although the scope and number of papers for smart cities are limited, these selections serve as a recent forum to present innovative and new developments that are highly relevant to the scope of this special issue.

## CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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