Date of current version April 30, 2020.
Digital Object Identifier 10.1109/ACCESS.2020.2988125

EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: URBAN COMPUTING AND WELL-BEING IN SMART CITIES: SERVICES, APPLICATIONS, POLICYMAKING CONSIDERATIONS

Over the past decade, the status of smart cities changed from a fancy area of research into a key policy-making consideration. The increased attention paid to smart cities by decision-makers and politicians prompted in turn a new wave of research in the domain. Urban computing is but one of the developments thus prompted. As this Special Section depicts, it is also one of the most promising domains of research likely to transform the debate on smart cities in the years to come. Urban computing offers a conceptual and methodological framework that integrates the plethora of increasingly sophisticated technologies and their applications in city/urban space. It offers a framework suitable to conceive of andbuild synergies, and to apply in the city/urban space context a variety of approaches and techniques. These include pervasive computing, big data analytics, crowdsourcing, and volunteered geographic information such as user behavior, brand popularity, recommender systems, and social media analytics. In this way, urban computing bears the promise that targeted solutions will be found for the challenges cities/urban spaces face. The objective of this Special Section in IEEE ACCESS was to explore that promise from a variety of complementary interdisciplinary perspectives, including computing/ICT, political economy, public policy, innovation, and entrepreneurship.

The pace of urbanization is increasing. Today, about 50 percent of the world's population lives in cities. By 2030 the percentage is bound to increase to 60 percent or more [item 1) in the Appendix]. For a variety of reasons, this pace of urbanization is a source of multiple challenges. The increasing development of ubiquitous technologies are producing a wealth of information, reflecting different features of our lives over the last decade. Digital traces emanating through our daily interactions with pervasive computing devices are valuable sources of data for capturing the pulse of the city in an astonishing degree of temporal and spatial detail.

Urban computing occupies an important position in smart cities, and rapid urbanization presents a crucial challenge worldwide. Thus, many initiatives and technologies are being taken into consideration that can be continuously modified to provide developments and policymaking strategies in any city. Indeed, the rapid population growth in urban areas has created many problems in modern cities such as greater pollution, more traffic congestion, and the need to satisfy higher demand for energy and sanitation services. In this context, considering the challenges and opportunities cities/urban spaces generate, today the imperative is to examine how targeted research and cutting-edge innovation can be effectively communicated to all stakeholders. Thus, synergies emerging at the research-innovation-policymaking nexus can be exploited and city dwellers' well-being can be enhanced.

The problems associated with urbanization need smart solutions that involve human capital, creativity, and collaboration with various stakeholders [item 2) in the Appendix]. Hence, urban computing serves as a key framework that integrates increasingly sophisticated technologies pertinent to the context of smart cities, such as Internet of Things, pervasive computing, big data analytics, crowdsourcing, and volunteered geographic information including user behavior, brand popularity, recommender systems, and social media analytics, bears the promise and potential that viable solutions to key problems and challenges specific to cities/urban spaces will be solved.

Urban computing for city planning is one of the most significant applications in ubiquitous computing. It has largely been applied either in relatively homogeneous rural areas, where researchers have added sensors in places such as forests and glaciers, or in small-scale, well-defined patches of the built environment, such as smart houses or rooms. Urban areas are more complex and interesting spaces because they offer information that characterizes the dynamic of the cities.

Although urban environments are focused on being far more dynamic in terms of what and who would participate in an application or system, urban spaces also bring us a lot of opportunities to explore novel systems and applications facilitating people's lives and serving the city. Emerging in these circumstances, urban computing presents a new ubiquitous computing concept where each sensor, person, vehicle,

building, and street in urban areas can be used as a computing component for serving people and the city.

Moreover, urban computing is a multi-disciplinary research field, where computer science meets conventional city-related areas such as civil engineering, transportation, economics, energy engineering, environmental science, ecology, and sociology. Thus, this Special Section is centered on discussing the aforementioned issues from the perspective of computer engineering.

Summing up, the relationship between smart cities and their influence on applied smart urban computing for developing new strategies that face public policymaking in social-economic growth is a novel and emerging research area in the domain of computer science. This Special Section provides a timely edition for the exchange of state-of-the-art research results in many fields directly related to the sustainability of smart cities and the promise and potential variety of complementary interdisciplinary fields. The research topics that have been explored in this Special Section aim to play an important role in the next generation of smart applications and in the development of public policy-making for social-economic growth in big cities.

This Editorial is organized as follows: This next section presents a general discussion of the accepted articles, highlighting the most important contributions in smart cities and urban computing areas. The following section outlines a general discussion regarding this Special Section and our experience and conclusions from this research work.

This IEEE ACCESS Special Section on Urban Computing & Well-Being in Smart Cities: Services, Applications, Policymaking Considerations, aims to bring together researchers to disseminate their findings in fields such as:

- ICT and their role in the integrative knowledge management systems for smart cities
- application of public policies aimed at boosting research and innovation for smart cities
- smart generation of volunteered information to finance research and innovation promotion in smart cities
- pervasive computing applied in the transformation of cities to smart cities
- smart and collaborative mobile applications to analyze human dynamics in big cities
- the role of cryptocurrency technology for social economic growth in smart cities
- case studies based on Internet of Things and big data analytics technologies applied to smart cities
- enhancement and strategic development of skills and competencies for the required digital transformation to develop public policymaking
- advanced computing approaches and systems for international business leadership in the context of smart cities.

This Special Section will also examine the building of international innovation networks enabled by:

- sound technological innovative applications for the sustainability of smart cities
- blended approaches to smart cities research
- smart and open data acquisition and processing
- pervasive and mobile computing to analyze the social impact in smart cities
- cloud computing for smart services inside smart cities
- smart healthcare applications in the development of public safety policies
- big data analytics to smart data from smart cities
- virtual and augmented reality applied to smart cities applications
- crowd-sensing with 5G sensors to smart cities
- nanotechnology applied to successful cases in smart cities
- cognitive computing to describe behavior in the knowledge society
- regulatory and policymaking considerations, including the role of international organizations in context of smart cities and their evolution.

The Call for Papers for this Special Section was received with great enthusiasm in the scientific community. In total, 93 articles were submitted, of which only 22 articles were accepted. The first article, ''Drift-aware methodology for anomaly detection in smart grid,'' by Fenza *et al.* describes a novel anomaly detection method to avoid energy waste, tackling the concept drift. This approach adopts a long short-term memory network to provide an estimate of the consumers' behavior taking into consideration past consumption. Thus, a model to predict errors regarding consumption is proposed to detect possible anomalies based on continuous monitoring.

The article, ''Diversified routing queries in dynamic road networks,'' by Li *et al.* proposes a novel analysis of diversified routing queries in order to find out the most convenient routes in dynamic networks. The analysis reflects the interaction of three important variables: Travel time, congestion probability, and global travel cost. These types of queries are very suitable in mobile applications, which are focused on location-based services, intelligent planning transportation, and urban computing.

In the article, ''A cloud-based real time polluted gas spread simulation approach on virtual reality networking,'' by He *et al.* a flexible model to simulate polluted gas in a large-scale 3D online virtual world is presented. The approach consists of using computational fluid dynamics in a cloud computing environment. This solution simulates the movement patterns and real-time and spatio-temporal dynamics of polluted gas spread in a large-scale scene with online ordinary computer equipment. The contribution is oriented towards providing a basic method for urban computing and policymaking of smart cities.

In the article, ''Is DNS ready for ubiquitous Internet of Things?'' by Yan *et al.* a theoretical analysis based on a set of characteristics such as name, security, mobility, infrastructure independence, localization, and efficiency are integrated and referred to as the SMILE method. It is focused on describing whether the domain name system (DNS) is

prepared to support the ubiquitous Internet of Things (IoT) in order to empower this vision into the most important infrastructure in the current Internet. Authors propose an evolution of the DNS with an IoT environment in order to provide many computing services in smart cities.

With respect to the article, ''Identifying the components and interrelationships of smart cities in Indonesia: Supporting policymaking via fuzzy cognitive systems,'' by Firmansyah *et al.* a real case study of multiple Indonesian cities to determine their smart city status is presented. The outcomes are intended to clarify interrelationships for use and structural support in policymaking, in order to define cognitive maps and their application in public policies aimed at boosting research and innovation for smart cities.

The article, ''Big data in motion: A vehicle-assisted urban computing framework for smart cities,'' proposed by Murk *et al.* is centered on providing a novel and efficient data-transfer framework based on user-generated content, particularly volunteer vehicles carrying data in the destination direction. This architecture promotes self-belonging, social awareness, and energy conservation through urban computing encouraging participation by citizens. The present research work is envisioned to facilitate the well-being of society through optimal configuration of a vehicular data transfer network based on analysis of delay, energy consumption, and data-spot utilization.

Due to the rapid development of urban rail transit, in the article, ''Subway passenger flow forecasting with multi-station and external factors,'' Yan and Wan propose a multi-type-attention-based network, to forecast subway passenger flow with multi-station and external factors and historical data. The presented model is oriented towards forecasting the passenger flow, travel, and the subway dispatch, contributing to improving the performance of this service in different cities in China.

In the article, ''Distributed architectures for intensive urban computing: A case study on smart lighting for sustainable cities,'' Mora *et al.* propose an architecture based on a combination of cloud and mobile computing technologies, which is composed of three-layer distributed architecture for intensive urban computing. This research work was tested by defining a case study on smart lighting in order to illustrate the benefits of using the proposed model in smart city environments.

Alghamdi *et al.* propose the article, ''Decentralized electric vehicle supply stations (D-EVSSs): A realistic scenario for smart cities,'' in which the decentralization of power generation and management issues in electric vehicle supply equipment is taken into consideration. The contribution is centered on simulation results using realistic scenarios that are focused on validating the proposed schemes and demonstrating their efficiency and effectiveness while satisfying the defined constraints. Additionally, this approach was applied in scheduled and unscheduled schemes to Ontario highways.

The article, ''Optimal decision guidance for the electricity supply chain integration with renewable energy: Aligning smart cities research with sustainable development goals,'' is presented by Al-Nory. The contribution introduces a novel methodology and an optimization model for the electricity supply chain, which is addressed to reduce the variability of renewable energy source supply by optimal planning of supply chain operations. The methodology defines well-being as an affordable and clean energy primer, highlighting the innovation in the design and deliverable of a fully functional eco-system for the optimization of the electricity supply chain.

To provide a particular approach to collect high-resolution, real-time status of the unconnected road, Lv *et al.* present the article, ''LiDAR-enhanced connected infrastructures sensing and broadcasting high-resolution traffic information serving smart cities.'' The work introduces a novel method to analyze traffic congestion by means of LIDAR sensors and broadcast connected-vehicle messages through DSRC roadside units. The main contribution is addressed to accelerate the deployment of connected networks for smart cities in order to improve traffic safety, mobility, and fuel efficiency.

The article, ''Enhancement of ant colony optimization for QoS-aware Web service selection,'' presented by Alayed *et al.* is centered on enhancing the ant colony optimization (ACO) algorithm, which is based on a swap concept for the QoS-aware WSS problem. The main goal of this ACO enhancement is to reduce the search duration applied to many applications involved in the well-being of smart cities.

The article, ''Smart furniture as a component of a smart city—definition based on key technologies specification,'' by Krejcar *et al.* is oriented towards providing a recognition method for smart furniture, which indicates the collaboration between ICT and social-economic research. The contribution is centered on the sustainability of the environment, taking into consideration intelligent systems or controllers operated with the users' data and energy sources.

According to the circular economy topic in the context of sustainable development, Aceleanu *et al.* present the article, ''The management of municipal waste through circular economy in the context of smart cities development.'' It aims to identify a set of major actions recommended at the European Union level in order to promote this vision. As a case study, the progress achieved by Romania in the last ten years and the extent to which the country is prepared to implement efficient management of municipal waste in order to promote the circular economy vision is analyzed.

The research work, ''Reinforcement learning for improving the accuracy of PM2.5 pollution forecast under the neural network framework,'' by Chang *et al.* proposes the use of reinforcement learning (RL) to predict future PM2.5 values instead of artificial neural networks (NNs), combining linear autoregressive integrated moving average (ARIMA) models with nonlinear NN models. First, the Q-learning algorithm in RL based on its state characteristics on the NN model is applied. Second, the input with different input dimensions and values of time delay, which can calculate the best strategy, and evaluate the computational complexity of our RL algorithm, is selected.

For developing smart cities, it is necessary to integrate all components of a city as a system of systems. This is facilitated by urban computing as a technology to address the complexity of providing adequate services to citizens. In this context Javidroozi *et al.* propose the article ''Urban computing and smart cities: Towards changing city processes by applying enterprise systems integration practices.'' It aims at providing an understanding of similarities and differences between Business Process Change (BPC) challenges in the two contexts: Smart City Development (SCD) and Enterprise Systems Integration (ESI). This study collects data through literature analyses, interviews, and document analyses, and suggests that many BPC challenges in SCD have an equivalent from the ESI context.

The article, ''Investigating the intensive redevelopment of urban central blocks using data envelopment analysis and deep learning: A case study of Nanjing, China,'' presented by Qu *et al.* proposes a prediction method based on a deep learning model to determine the intensification of morphology of blocks that are the basic units of urban form and land management. The contribution highlights that this issue is a key point to sustainable urban development and for the optimization design of urban block morphology.

The article, ''Annotation of smart cities Twitter microcontents for enhanced citizen's engagement,'' by Alkhammash *et al.* proposes an approach that deals with semi-automatic annotation in smart city contexts, specifically the annotation of Twitter-content for the promotion of citizen's engagement. This research work involves the promotion of an open-collaborative semantic annotation framework in the social content of a smart city.

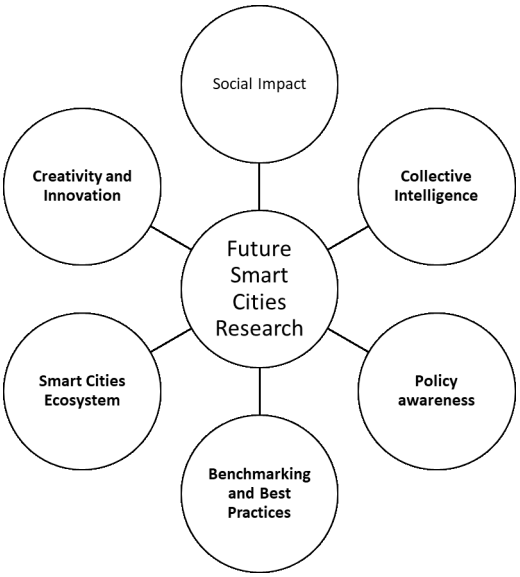
''An integrated big and fast data analytics platform for smart urban transportation management,'' is presented by Fiore *et al*. This issue is considered as a multifaceted big data challenge; thus, this article is focused on implementing a public transport analytics application, particularly the City Administration Dashboard for the Municipality of Curitiba, Brazil. This solution offers a scalable big and fast data analytics platform, and flexible cloud computing infrastructure.

The article, ''A reinforcement learning-based framework for the exploitation of multiple RATs in the IoT,'' by Sandoval *et al.* proposes a framework to allow IoT nodes to learn from previous real-world data in order to derive optimal Radio Access Technologies-selection policies. These policies were implemented with Artificial Neural Networks to maximize a predefined reward closely related to classic throughput, while maintaining power consumption and operational costs below a certain limit. To evaluate the research work, a network of 1000 devices deployed in the city of Chicago was simulated. The results were compared to those achieved with other intuitive policies to further highlight the benefits of the proposal.

Urban geological information management systems are an important trend in the development of smart geology and big data. The article, ''Key technologies of a large-scale urban geological information management system based on a browser/server structure,'' proposed by Zhou *et al.* presents three types of technical tasks to construct an urban geological information management system based on a B/S structure. In this context, a geological information management system for a city in eastern China was developed.

The article, ''Geospatial modeling of road traffic using a semi-supervised regression algorithm,'' presented by Saldaña-Perez *et al.* proposes a model to predict traffic congestion applying a support vector machine approach. In addition, a crowdsourcing approach based on mining Twitter social networks collecting events associated with the traffic was designed. The main contribution of this research work is focused on providing a methodology that characterizes traffic congestion analyzing crowd-sensed data from a geospatial perspective.

Within the interdisciplinary context of smart cities research and urban computing, six integral pillars summarize the next important milestones:



1. Social Impact: The integration of sophisticated information systems' research with social sciences in order to justify the social implications and social value of smart cities applications. To this direction, more detailed studies on perceptions of smart cities' users and understanding of their concerns should be encouraged [item 3) and 4) in the Appendix].

2. Collective Intelligence: One of the greatest challenges for future smart cities research is related to the design, implementation and support of fully functional, flexible and personalized smart cities services capable of collecting the collective intelligence of individuals and teams combined with additional sophistication from the internet of things ecosystem.

3. Policy Awareness: Future urban computing applications need to exploit, in a well-organized and directed way, policy awareness related to critical sustainable development goals,

as well as social inclusive economic growth. Social issues as well as societal challenges provide research areas for future investigation [item 5)–7) in the Appendix].

4. Benchmarking and Best Practices: The standardization and interoperability of smart cities services beyond technological and geographical barriers and limitations is a key challenge for the future. A key requirement is to promote research related to standardization at a global scale [item 8) in the Appendix].

5. Smart Cities Ecosystem: The evolution of future smart cities research requires an advanced, distributed, innovative ecosystem of services, applications and infrastructures along with detailed mapping of services, annotation of content, and securing of private data profiles [item 6) in the Appendix].

6. Creativity and Innovation: The final direction of future smart cities research is related to creativity and innovation. Blending technologies, claiming new unchartered areas of human creativity, and capitalizing on multi-cultural integration and uniqueness will be a must for the next decade of smart cities research.

Summing up, urban computing is an interdisciplinary science, which explores how real-time technologies can help us better understand our cities, as well as conceiving possibilities of how these technologies can improve our cities.

The discussion and making of smart cities also requires direct involvement of the citizens. Clearly, one of the challenges in this respect is that many end-users of smart city applications are intimidated by the technological aspect of ICT-enhanced tools. The whole idea and broader framework are incomprehensible to too many people. Thus, the relevance and the added value of smart solutions are undermined.

At the center of the discussion on smart cities is the question of the ethically and socially sensitive use of ICT-enhanced tools and applications in the city space, starting with privacy issues, through questions of democracy, participation, representation, and expanding beyond questions of inclusion, well-being, and prosperity.

This Special Section originates in the recognition that smart cities should be better understood by a broad spectrum of stakeholders. The technological sophistication of several topics pertinent to smart cities research notwithstanding, the rationale behind this Special Section was intended to facilitate readers otherwise ignorant of the topic to get a fair idea of what a smart city actually is.

We would like to thank all the contributors to the Special Section for their excellent collaboration and valuable scientific contributions. The quality of their research and their passion for making science valuable to urban computing and well-being in smart cities is reflected in every article in this work. We are also grateful to the referees for their dedication, and the members of the editorial team of IEEE Access. Without their support this achievement would not have been possible.

APPENDIX
RELATED WORKS

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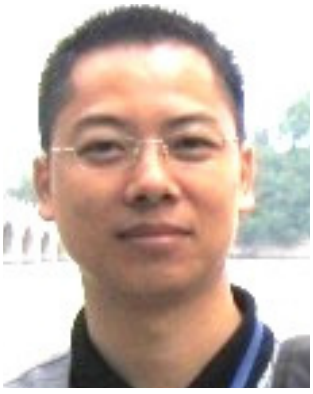

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