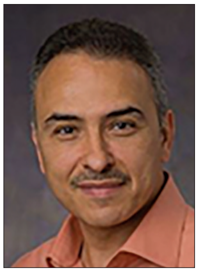
Crowd Management



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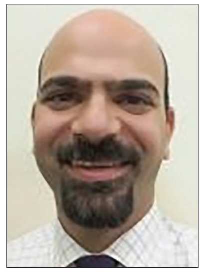

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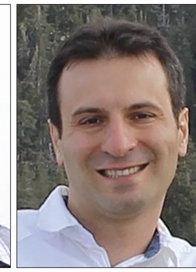

Mutaz Shukair

In its 2018 Revision of the World Urbanization Prospects, the United Nations projects that 68 percent of the world's population is expected to be living in urban spaces by 2050, compared to the current 54 percent and 30 percent in 1950. The main drive for urbanization has been economic, with the general population seeking better employment opportunities accompanied by improved lifestyles. Such increased urbanization rates put significant pressure on city infrastructure networks and challenges existing methods for various aspects of governance, including crowd and traffic management. In particular, phenomena such as rush hours and special events carry significant challenges and risks. Environmental impacts due to massive urbanization are also on the rise. These and other indicators call for new management mechanisms for crowds, especially those exploiting recent advances in technology, e.g., the Internet of Things (IoT) and big data.

Recently, the ubiquitous use of smartphones has motivated great interest in utilizing them for various sensing applications. In addition to its powerful communication and computing capabilities, the typical smartphone possesses a wide array of sensing capabilities (camera, microphone, gyroscope, accelerator, GPS, thermometer, barometer, etc.) that enable its use in a wide range of applications. These advances in smartphone technology coupled with their ubiquity have paved the way for an exciting new paradigm for accomplishing large-scale sensing, known in the literature as crowd sensing (CS). The key idea behind CS is to empower ordinary citizens to collect and share sensed data from their surrounding environments using their smartphones.

An equally important area of research is analyzing and making sense of this crowd-sensed data to extract information that is useful for managing the movement of crowds, known as crowd management (CM). CM is of huge importance as it translates sensed values into tangible actions and predictions. For example, the use of CM has been investigated and implemented in both the pedestrian and vehicular environments, as well as in recognizing various levels of crowd activity.

A major component that impacts the whole process of CM is the sensing infrastructure and its level of smartness. Such smart infrastructures for CM are a hot topic under consideration in recent research due to their impact on the broad disciplines of IoT, big data, CS, CM, and so on. Some characteristics of the infrastructure and its level of smartness would require long-term analysis that is mainly achieved through offline inferences. The objective of this Feature Topic is to understand the impact of smart infrastructures on CM mechanisms. A main concern is how to achieve scalability, while also ensuring the ability to deal with different kinds of crowds (e.g., pedestrians, bikers, cars, autonomous cars, emergency vehicles) and scenarios (e.g., residential buildings, governmental buildings, service buildings, roads, parks). At the core of the smart infrastructure realization is a closed-loop sense-process-act cycle. This core relies heavily on state-of-the-art advances in sensing, computing, and telecommunications/networking, and proceeds with considerations for both evolutionary setups (i.e., smartening up traditional infrastructures) as well as new infrastructure implementations.

The scope of this Feature Topic falls within recent efforts of both engineering and research communities to realize a smart city, which takes advantage of its communication infrastructure and computing/sensing capabilities to sense, filter, process, infer, and react, in order to enhance the city's sectors of traffic management, health and air quality, weather, business, and education, among others. The contributions in this Feature Topic are divided into three parts. Part one focuses on data analytics and management, and comprises five very interesting articles giving insights to the reader about CM and its usage in practical systems. The second part contains two articles discussing consideration of the crowd-sensed values in CM for emergency situations, which is a very vital concept for smart cities. The last part is composed of four articles focusing on the social and data sharing challenge that arises when collecting information from the crowd to achieve the objective of CM, and also the influence of smart infrastructure on such data sharing.

The first part opens with the article "Crowd Management: A New Challenge for Urban Big Data Analytics" by Celes *et al.*, which explains how the pervasive availability of urban data provides unprecedented opportunities for analyzing several situations in cities The authors analyze the types of crowd situations, describe the major categories of urban data, and highlight their strengths and weaknesses. Moreover, through case studies, the authors explain how to apply urban data for spatial, temporal, and semantic observations of crowd situations.

This is followed by the article "Monitoring a Crowd's Affective State: Status Quo and Future Outlook" by Taha *et al.*, which focuses on evaluating the effects of crowd monitoring by reviewing the recent advances and enabling technologies in affective sensing at both the individual and crowd levels. Further, this article also remarks on deployment considerations in affective sensing architectures and discusses the area's current key outstanding challenges.

A knowledge mining model is presented in the article "Self-

Aware Autonomous City: From Sensing to Planning" by Chen *et al.*, which can be used by city planners for orchestrating future development projects. The knowledge collection of city dynamics relies on swarm intelligence. City planners can utilize the collected data and context-aware collaborative filtering for resource/crowd prediction during city expansion. With the proposed model, a city can estimate the requirement for resources when the peripheral areas on the outskirts of a city undergo development.

Solmaz *et al.*, in their article, "Toward Understanding Crowd Mobility in Smart Cities through the Internet of Things," discuss the new advancements toward smart cities using IoT. The article proposes the usage of the new federated interoperable semantic IoT platform (FIESTA-IoT). In particular, it discusses two integrated IoT systems for crowd mobility:

1. Crowd Mobility Analytics System
2. Crowd Counting and Location System

The pilot studies conducted show the capability of the systems to fulfill various requirements and share information across different stakeholders by leveraging the IoT technologies and infrastructure.

Next, Boukerche *et al.*, in their article "Crowd Management: The Overlooked Component of Smart Transportation Systems," discuss the incompleteness of current smart transportation system initiatives for smart crowd management. Moreover, the authors identify and discuss the basic steps for the design of solutions for smart crowd management, as well as the main challenges that must be addressed. Finally, future research directions for the design of smart crowd management solutions and infrastructures for smart transportation systems are presented.

The second part begins with the article "A Communication Architecture for Crowd Management in Emergency and Disruptive Scenarios" by Perez *et al.*, which proposes the communication architecture for crowd management (CACROM) that can support crowd management for emergency and disruptive scenarios. The authors describe and discuss the architecture, and finally outline future research issues that require further attention.

The next article, "Joint Crowd Management and Structural Health Monitoring Using Fiber Optic and Wearable Sensing" by Mustapha *et al.*, introduces a joint structural health monitoring and crowd monitoring framework using a combination of fiber optic sensors installed along structures and wearable sensors carried by crowd participants. The framework employs novel fiber optics sensing technology for measuring structural strain for the purpose of crowd load estimation.

The last part of the Feature Topic focuses on the challenge of social and data sharing. The first article in this part, "A Social-Driven Edge Computing Architecture for Mobile Crowd Sensing Management" by Bellavista *et al.*, introduces a new social-driven edge computing architecture based on incentives and centrality measures. The core idea is to add social multi-access edge computing (SMEC) nodes to complement the traditional edge nodes acting as bridges between other devices and the cloud. In addition, the authors report extensive experimental results based on co-location traces and cooperativeness.

Nie *et al.*, in their article "An Incentive Mechanism Design for Socially Aware Crowdsensing Services with Incomplete Information," first introduce basic concepts of socially aware crowdsensing services and highlight the importance of "social network effects." The authors propose a game model for an incentive mechanism design with incomplete information about the social network effects in socially aware crowdsensing. The proposed model is shown to improve the benefits of the crowdsensing service provider as well as the users.

In the next article, "Data and Service Management in Densely Crowded Environments: Challenges, Opportunities, and Recent Developments" by Aloqaily *et al.*, the authors highlight the challenges that arise in crowded environments in terms of data/service management and delivery. Next, the authors discuss data replication and service composition as promising solutions for data and service management in dense crowded environments. This article also outlines how services can be composed in crowded environments using service-specific overlays, where these overlays are created through the collaboration of multiple edge and mobile devices to deliver composite services to users.

In the concluding article, "Routing for Crowd Management in Smart Cities: A Deep Reinforcement Learning Perspective," Zhao *et al*. present a Deep Reinforcement Learning-Based Smart (DRLS) routing algorithm, which makes the distributed computing and communication infrastructure thoroughly viable while simultaneously satisfying the latency constraints of service requests from the crowd. Their objective is to alleviate the network congestion and balance the network load for supporting smart city services with dramatic disparities. Besides the proposed algorithm, extensive numerical results are also presented to validate the efficacy of their algorithm.

Biographies

HOSSAM HASSANEIN [F'17] (hossam@cs.queensu.ca) is a leading authority in the areas of broadband, wireless and mobile network architecture, protocols, control, and performance evaluation. His record spans more than 500 publications in journals, conferences, and book chapters, in addition to numerous keynotes and plenary talks in flagship venues. He has received several recognitions and best paper awards at top international conferences. He is also the founder and director of the Telecommunications Research Lab (TRL) at Queen's University School of Computing, with extensive international academic and industrial collaborations. He is a former chair of the IEEE Communication Society Technical Committee on Ad Hoc and Sensor Networks (TC AHSN).

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