International Workshop on Smart City: Control and Automation Perspectives

The International Workshop on Smart City: Control and Automation Perspectives was held at the Zhejiang Hotel in Hangzhou, China, on August 27–29, 2013. The workshop was supported by Hangzhou Dianzi University, the IEEE Control Systems Society (CSS) Outreach Fund, the Zhejiang Research Center for Smart City, Honeywell International, and the Zhejiang Province government. The objective of the workshop was to establish a platform for triangular parties—government, industry, and academia—to exchange ideas, discuss challenges, and put forward possible solutions in the hope that a more interactive community forum could be developed to define and address the problems associated with the smart city. These problems include resource consumption, environmental degradation, security, and congestion. Twelve experts from the United States, Europe, and Asia were invited to deliver plenary talks on various topics to the 120 participants.

To concentrate on the key topics, the organizers structured the workshop to have two layers of interaction. In the first two days, presentations and discussions mostly centered on specific themes were followed by two panel sessions. In the last half-day, a roundtable discussion session was arranged for invited government officials, industry representatives, and academic faculty members to talk about the critical issues and challenges and to brainstorm possible solutions from a more practical perspective.

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Tariq Samad, general cochair, summarizing highlights of the workshop presentations and discussions.

KEY TOPICS

As has been demonstrated in the broad application of industrial and academic research results, control systems could be employed in many aspects of a smart city. A few examples include scheduling algorithms for energy distribution in smart grids, predictive control for city water management systems, automation with feedback in road traffic management systems, and sensor networks for applications such as environmental monitoring and security. More applications of control systems for the smart city will emerge if the control research community could better understand challenges and opportunities posed by cities through the interaction with city governments and industry players.

In this workshop, participants and invited speakers discussed the application of control technology to various areas of the smart city. In particular, the following topics were explored:

- smart logistics/transportation
- smart water
- smart energy/grid
- smart manufacturing
- smart security.

SUMMARIES OF INVITED PRESENTATIONS

The workshop featured 12 presentations delivered by prominent researchers

Anke Xue, president of the host institution, Hangzhou Dianzi University, and general cochair of the workshop, delivering the opening speech.

The morning session on the second day of the workshop.

Members of the Organizing Committee and invited speakers (from left): Hock Beng Lim, Vladimir Havlena, Karl Henrik Johansson, Carlos Canudas-de-Wit, Shinji Hara, Anke Xue, Scott Moura, Tariq Samad, Venkat Venkatasubramanian, Bohu Li, Ming Ge, Deyi Li, and Raja Sengupta.

with expertise in a broad array of smart city-related topics, from technology-specific issues to a macro-level overview of smart city relevant challenges. These presentations are summarized below.

Prof. Venkat Venkatasubramanian, codirector of the Center for the Management of Systemic Risk, Columbia University, United States, presented an overview of challenges facing the city and provided a control-theoretic framework for the management of systemic risk. He argued that a better city needs not only an "IQ" (intelligence quotient) aspect, which emphasizes efficiency, reliability, robustness, optimization, and sustainability with advanced technology in computers, communication, and controls domains, but also an "EQ" (emotional quotient) aspect that goes beyond pure engineering and focuses on human elements and social elements such as happiness, satisfaction of basic needs, and community interaction.

Prof. Fei-Yue Wang, director of the State Key Laboratory of Management and Control for Complex Systems, Institute of Automation, Chinese Academy of Sciences, proposed the "ACP-based parallel control and management approach," essentially a data-driven approach for modeling, analysis, and decision making, as a new mechanism for conducting operations of the smart city as a complex system that deeply involves intricate issues of both engineering and social dimensions.

Prof. Shinji Hara of the University of Tokyo, Japan, proposed the idea of "glocal control" and a framework for hierarchical large-scale networked dynamical systems, which employs local actions of measurement and control to serve a global purpose. Two applications of glocal control were introduced: the management of energy network systems consisting of a variety of energy resources by hierarchical decentralized control and the design of a control network structure for realizing a "smart water city."

Prof. Dr. Hock Beng Lim, the director of the Intelligent Systems Center, Nanyang Technological University, Singapore, presented a unified R&D framework to support the development of technologies for smart cities. His team's recent efforts were highlighted in the development and deployment of city-scale systems for applications including weather and environmental monitoring, water distribution network monitoring, transportation activity surveys, and smart and energy-efficient buildings in Singapore.

Prof. Deyi Li, academician of the Chinese Academy of Engineering, presented location-based service (LBS) applications in smart driving and smart transportation, which has seen widespread use in smart city applications with the technology breakthroughs in cloud computing and global positioning systems. Prof. Li argued that LBS serves as the basis for many smart city applications and the improvement of LBS such as accuracy of the position system and computing capability will be central to the success of its applications.

Dr. Carlos Canudas-de-Wit, the director of research at CNRS, GIPSA-Lab, Grenoble, France, shared his Grenoble Traffic Lab initiative on the setup of a real-time traffic data center with

Venkat Venkatasubramanian gave the opening plenary, "Managing Systemic Risk in Complex Sociotechnical Systems."

Karl Henrik Johansson's presentation, "Control and Optimization of Future Goods Transportation," was one of several on smart transportation.

minimum latency and fast sampling periods. He reviewed the main conservation models for physics-oriented forecasting and control algorithms and presented advances in traffic forecasting using graph-constrained macroscopic models that substantially reduce the number of possible affine dynamics of the system and preserve the number of vehicles in the network.

Prof. Karl Henrik Johansson, director of the KTH ACCESS Linnaeus Centre, Royal Institute of Technology, Sweden, discussed the challenges for goods transportation, which is increasing dramatically as the world develops. He explained in detail how modern information and communication technologies (ICTs) can support a future goods transportation system where trucks in a fleet are coordinated to travel together in vehicle platoons. Control and estimation challenges on various levels of this transportation system, were highlighted and feasible solutions with a coherent system architecture were presented.

The theme of smart transportation was elaborated further by Prof. Raja Sengupta of the University of California, Berkeley, United States, who discussed the broader leverage of ICTs to smarten the cities of the future. Prof. Sengupta revealed that ICTs have a revolutionary impact on the demand side and presented his perspective on the NextGen Intelligent Transportation initiative that utilizes ICTs to help adapt citizen behavior to city transportation services for the benefit of both city and citizen.

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Electrified transportation creates unique mobility options and constraints while simultaneously imposing new energy demands and storage opportunities. To address this, Prof. Scott Moura of the University of California, Berkeley, talked about his group's work on thermostatically controlled loads (TCLs) in the built environment. His research centers on exploiting the inherent flexibility of TCLs to achieve city- or region-wide benefits via demand response. By leveraging state-estimation techniques, a minimal sensing and communication infrastructure can be implemented to monitor and control a diverse population of TCLs.

Dr. Vladimir Havlena, senior fellow at Honeywell Laboratory, Prague, Czech Republic, provided an overview of distributed optimization methods and their application to municipal water management systems, which have long been considered a pivotal component of a smart city. Performance and benefits from distributed model predictive control were illustrated by application to the control and energy efficiency optimization of the transport layer of a large city water management system in Barcelona, Spain.

In addition to these topics, Prof. Bohu Li, academician of the Chinese Academy of Engineering, presented his recent research results in cloud manufacturing—a new pattern and approach for manufacturing in smart cities. Cloud manufacturing is a novel, networked, intelligent manufacturing model that is service oriented, knowledge based, and energy efficient.

CHALLENGES

Challenges and open issues that were raised and discussed for the most part fell into four categories:

- *Government's role.* A city is a complex system so that effecting changes and improvements requires all stakeholders to pull together and make united efforts. The city and/or provincial government are required to lead the efforts and facilitate the collaborations between different departments and agencies.
- *Control framework.* Control and automation technologies have been broadly used in many aspects of the smart city. However, a unified control system architecture tailored for smart cities has not yet been developed in spite of

Raja Sengupta continued the smart transportation theme with the lecture, "Adapting the Citizen to the City: NextGen Intelligent Transportation."

Urban manufacturing infrastructure was the topic of the "Cloud Manufacturing" lecture by Bohu Li.

Ge Ming, program chair, reviewing the technical program.

the new ICTs developing in a seemingly endless stream.

» *Sociotechnical problem.* The fundamental element of the city is the human being. In addition to the physical form of city infrastructure, the underlying structure that supports our cities, the "nonphysical" infrastructure that consists of social, political, economic, and cultural support systems has to be considered in tackling technical challenges facing the smart city.

» *Cross-domain collaboration.* The complexity of the smart city requires interdisciplinary and cross-institutional collaborations between industry, academe, and government.

Despite—and because of—the challenges and open issues outlined above, participants all agreed that this is the right time to address smart city problems from a controls perspective, with advances in areas such as sensing, mobility, and information technologies providing enablers for advanced algorithms for big data mining, location-based services and apps, monitoring, estimation, control, and optimization.

FUTURE WORK

While control and automation technologies have seen increasing application to smart cities, a lot of work needs to be done to address the open issues and challenges described here. A few recommendations for future work are as follows:

» *Benchmark problems.* A constraint on current research is that academe lacks an in-depth understanding of customer needs. An effective solution to this limitation is the framing of typical benchmark problems abstracted from industrial applications. The benchmark problems should represent the most common challenges encountered in real applications. It is recommended that these problems be coformulated by both industry and academic experts.

» *Pilot programs.* The best way to verify and validate the new technology and solutions is their deployment in pilot programs before undertaking large-scale applications. The identification of a few pilot programs that involve technologies from different disciplines (such as controls, computers, and communications) would strengthen the smart city-related research and cultivate interdisciplinary and cross-institutional collaboration.

» *Workshops and forums.* Workshops, seminars, and forums are highly recommended to be held regularly for the exchange of ideas, experience, and lessons among industrial and academic partners as well as government representatives.

A full report is available on the Web sites of the CSS Outreach Fund (http://ieeecss.org/sites/ieeecss.org/files/IntWorkSmartCityCSSReport.pdf) and the official Web site for the workshop (http://smartcity.hdu.edu.cn). The latter includes presentations from the workshop as well. As a result of this workshop, the CSS is in the process of establishing a new Technical Committee for Smart Cities.

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» HISTORICAL PERSPECTIVES *(continued from p. 99)*

in connection with the alleged anti-semitism in Soviet mathematics. At the invitation of Jerry Mendel, Professor at USC, Professor Pontryagin responded to the accusation in the *Science* article. Since the name of Pontryagin is so well known to the members of the Control Systems Society, the Newsletter is reprinting the *Science* article and professor Pontryagin's reply.

Items 1 and 2 are available at the *Science* Web site [2]–[3].

There was a consensus among the AdCom that the CSS had done the right thing. This activity led to the formation of a CSS Human Rights Committee, of which I was the first chair.

I was also editor-in-chief (EIC) of *TAC* (1973–1974). My regrettably short tenure as EIC was due to leaving McDonnell Douglas and starting at the University of Southern California in a visiting position in February 1974, for which there was not enough secretarial support for the EIC job. I was also vice president for Technical Activities (1983–1984), president elect (1985), and president (1986). I enjoyed all of my activities with the CSS, most of all being given the opportunity to meet and work with a wonderful group of people. Thanks again.

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