Control Challenges for Social Systems

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Abstract: The challenges in Social Systems, that are intensifying years after years, are addressed by the IFAC Coordinating Committee CC9 *'Social Systems'* and its five Technical Committees: *TC 9.1. Economic, Business, and Financial Systems; TC 9.2. Social Impact of Automation; TC 9.3. Control for Smart Cities; TC 9.4. Control Education; TC 9.5. Technology, Culture and International Stability (TECIS).* New domains of interest and new methodologies are emerging. This field exists at the crossroads of several disciplines where Control and Automation are playing a major, even critical, role. CC9 has undergone a re-organization in the last 6 years so as to meet these new control challenges. This extended abstract sketches the main objectives of its five IFAC Technical Committees, how they are organized and the main current methodologies. A full version of this extended abstract, including perspectives of this area, is expected to be submitted in the coming months.

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TC 9.1. ECONOMIC, BUSINESS, AND FINANCIAL SYSTEMS

In recent years, it has been widely witnessed and recognized that human activities in physical economic, business and financial systems have been increasingly extended into the virtual cyber and social spaces, creating prosperous online business models including computational advertising, E-commerce and Fintech, as well as socialized sharing economy. Compared with the one-fold physical system, these newly-emerging, large-scale and interconnected Cyber-Physical-Social systems (CPSS) exhibit complex dynamics evidenced by high uncertainty, diversity, and complexity, and thus are typical complex systems. Such social aspects as user psychology and behavior can further increase the CPSS's social and engineering complexity, making it intrinsically intractable for dealing with economic, business and financial problems in these highly dynamic and uncertain market environments with diversified trading mechanisms and complex user behavior and strategies. TC 9.1 focuses on all aspects of modeling, analysis, synthesis, control, and management in the economic, business, and financial CPSS Systems. Specially, TC 9.1 aims to study three key research questions on such aspects as modeling, experimentation and decision-making, namely 1) how to identify the intrinsic relationship between the microscopic individual-level modeling and the macroscopic system-level emergence phenomenon, based on such methodologies as reductionism and holism. 2) how to effectively design and conduct computational experiments so as to help predict and guide the "human-in-the-loop" CPSS systems; 3) how to make optimal decisions on managing and controlling the complex economic, business and financial systems, which are cohabitating and co-evolving in the parallel cyber, physical and social spaces. Towards this end, TC 9.1 aims at bringing together scientists and practitioners with different theoretical and methodological background covering econometrics, statistics, control science, computer sciences, operations research, and management science, among others. TC 9.1 also established three working groups: Group 1 focuses on Control-decision/applications in Business; Group 2 on Control-decision/applications in Finance; and Group 3 on Control-decision/applications in Economics. To summarize, TC 9.1's vision is to tackle the uncertainty, diversity, and complexity in modern economic, business and financial CPSS systems, study and provide effective solutions to those key research questions on the aspects of modeling, experimentation and decision-making, and thus evolve the

"invisible hand" behind the complex market phenomenon to the next level of "smart hand".

TC 9.2. SOCIAL IMPACT OF AUTOMATION

The scope of TC 9.2 focuses on the impact of automation and control sciences on society and environment. This topic is all the more important since automation and control technology are increasingly developed and used in our professional and/or personal life. One of the results of this increase is the emergence of new behaviours of both humans and machines that involve new balances of the mutual influence between technologies and society and that justify revisiting the traditional vision of the role that automation technologies play in our society. The TC 9.2 addresses positive and negative effects of automation on work, culture, health, safety, environment, as well as ethics of automation. The main challenge for the TC 9.2 consists in developing topics related to an Human-centered systems engineering for a socio-technical equilibrium (to mention a few: Systems thinking paradigms for an Human-centred systems engineering approaches, Balance between pushing Automation technologies and their suitable use by the Society, Human-centered approach versus techno-centered approach in enterprise networking, Automation and safety and security issues in society, Education and training versus expansion of industrial and manufacturing systems, Automation of Human-centered systems and Society). Attention is paid particularly on emerging applications of control sciences in areas such as autonomous systems (robots, vehicles, …), cooperation of multi-agents (in medical robotics, personal assistance, military/security and spatial robots), networks (internet, large distributed systems, tele-operation), interfaces and human computer interaction (as e.g. BCI), safety of process (e.g. fault tolerant control). TC 9.2 contains two working groups. Group 1 focuses on "Perspectives of a Human-centered systems engineering" and Group 2 works on "Cyber-Physical-Social Systems". The aims of those two working groups are to promote scientific exchanges on the relationship of cyber-physical systems with humans by studying different aspects: the design of cyber-physical system to humans, the impacts of cyber-physical system in society, and the potential for new impacts and improvements in citizens' lives in the future. The second working group had some meetings, one of them being organized in order to set up the first IFAC conference on Cyber-Physical & Human-Systems (CPHS'2016), which took place in Florianopolis, Brazil, December 7-9, 2016. This event was an opportunity to define a roadmap for the working group.

TC 9.3. CONTROL FOR SMART CITIES

The scope of TC 9.3 is to study smart cities as a control system and to encourage the research interactions within this area. Smart cities are complex systems involving multiple subsystems, and closely related to human lives. The research in the control for smart cities can be classified according to the application domains such as buildings, transportation systems, water systems, micro grids, healthcare systems, cybersecurity systems, just to name a few. There is also another viewpoint, which is to discuss the common challenges and methodologies in the control problems shared in these various domains. This TC encourages research and discussions in both viewpoints, which creates a good and open platform both for researchers who are already in the field of smart cities and also for newcomers who plan to enter the field in the short future. This TC was approved in October 2015 and is a young TC within the IFAC TC family. We start from small, and therefore do not split into various working groups for the moment. The members of this TC are not only active researchers in the field, but also reaching out to IEEE Control Systems Society, IEEE Robotics and Automation Society, and IEEE Power and Energy Society to jointly organize events or to provide technical sponsors. The complex nature of smart cities provides a great platform for the application of various existing control methodologies such as model-based predictive control, Markov decision process, and simulation-based optimization. In the meanwhile, the large scale and hierarchical dynamics of smart cities challenge the existing methods and provide opportunities for new research topics. For example, event-based or event-triggered control methods provide good trade-off between the complexity and the performance of the control law. Networked control or control over network may address the uncertain communication among the sensors and actuators across the city. Game theory may analyse the bottleneck of a transportation system or a micro grid and may design good mechanism for achieving good performance in the system-level through distributed and decentralized control actions. The theory of system of systems help to analyse the interaction among the various subsystems. The new techniques such as the internet of things also provide new opportunities for controlling smart cities. Smart cities may bridge the theoretical work and the applications in our community.

TC 9.4. CONTROL EDUCATION

Automatic control is one of the first systems disciplines that transcends the limits of the traditional engineering fields. An impressive number of control systems appear in practically all technological systems. Control is a pervasive discipline that is increasingly becoming mission critical in the sense that the system fails if the controller fails. The aim of TC9.4 is to promote the visibility of control in a more explicit way. This objective concerns the entire automatic control community. For that reason there are many opportunities in the control field. Some important areas include, among others, energy systems, nanoscale systems, networking systems, economics, and biology. The needs of industry for well-trained control systems scientists and engineers are changing, due to marketplace pressures and advances in technology. Future generations of engineering students will have to be broadly educated to cope with cross-disciplinary applications and rapidly changing technology. Current engineering education is quite successful in meeting some needs but falls short in others, especially those that are inherently multidisciplinary. Furthermore, the process fails to address, for the most part, educational needs of non-engineering students, who can

benefit enormously from engineering exposure and influence. Consequently, there is a great opportunity for the systems and control community to become actively engaged in this debate and take a leading role in shaping not only the future systems and control curricula but the broader engineering educational structure and content. In this sense the future of the control field will be non-traditional control approaches where we need to manage the dynamics of complex systems. To tackle this kind of problem will need people who are trained in feedback ideas with a systemic vision. As a control community we can have a strong impact on the solution of these problems. This TC regularly organizes 1) the IFAC Workshop on Internet Based Control Education (IBCE) that focuses on delivering control education using new information and communication technologies; 2) The IFAC Symposium on Advances in Control Education (ACE) that provides a forum at which researchers and practitioners in control education will present their latest research, results and ideas, including new knowledge and alternative approaches in education; 3) The award IFAC Harold Chestnut Control Engineering Textbook Prize which is presented at IFAC World Congresses for the best Control Engineering textbook.

TC 9.5. TECHNOLOGY, CULTURE AND INTERNATIONAL STABILITY

Technology development leads to dramatic changes in international stability and shapes, and is shaped by, culture and human values. Technology proliferation contributes significantly to the systemic and structural effects we are now experiencing in the international and regional context. Global systems of information, climate, finance, energy and migration, amongst others, have powerful consequences. In recent years international and national systems of control,especially in the social and political spheres, have proven inadequate and prone to fundamental instability. Many basic assumptions are no longer certain and are definitely questioned. IFAC, as a control systems and automation engineering community, recognises the need for radical new approaches by which to address these challenges. TC 9-5 (TECIS) is an almost unique community in that it draws together strands of thought and practice, as well as technological applications and solutions, from across a range of disciplines which share a common concern with the role of science and engineering in systems of international stability and the ways in which technology and culture interplay with each other. TECIS systematically examines these topics and explores the contribution of control science and automation engineering to solutions in this space. Members include visionary contributors from the commercial sector and non-governmental organisations as well as academia. TECIS encourages practical applications-oriented research as well as deep theoretical reflections. The Technical Committee comprises four working groups: Group 1 in Engineering Ethics, Group 2 in Cost-Oriented Automation, and Group 3 in Non-Technical Aspects of Technology Transfer and End-of-Life Management, Group four focussed on young and new IFAC members' inter-disciplinary contributions to our understanding of control and automation social effects in an international and inter-cultural context. This Emerging Control and Automation Engineers Working Group of people new to research is designed to provide an active support community for the development and nurturing of new ideas and vision. TECIS is annually organizing the IFAC International Conference on International Stability, Technology and Culture.

The work of these conferences and background activities is opening up new directions which are reviewed in the special sessions organised for the world congress. The sessions, in a real sense, reflect some of these developments. Firstly, thje contribution and relevance of IFAC generally and CC9 in particular to a peaceful and more stable world is emphasised. In 2017-18 the committee has successfully bid for and proposed a special issue of a major journal as a vehicle to unpack IFAC contributions in this space. Contributions have been as diverse as migration, control of financial systems, enhancement of cooperative measures, the role of (for example) supply chain integration logistics in global criminal activities, amongst many others. Another area has been the application of automation technologies to resource poor regions and contexts. This gave rise to a new working group focussed upon cost-oriented automation processes and technologies which contribute practical applications. Another area of development has been in the area of knowledge and technology sharing across borders. These are just a sample of developments which reflect the broad range of control and automation applications and theories which contribute to the improvement of international stability.

Into the future, TC 9-5, perhaps in cooperation with TC 9-2 and other IFAC TCs (such as in the area of transportation and logistics, as well as enterprise networks) see potential for work in the area of international institutional systems, especially the control of their behaviours. We are currently in talks with national safety agencies in advanced engineering contexts (cross- border transportation networks for example) to explore ways in which IFAC contributions can help deepen out understanding and provide insights into practical solutions for better control of risk and improvement of safety measures. This is in line with "risk philosophy" and "safety culture" which is a driving force in the emergence of new, advanced thinking about how to control for complex safety and risk factors, especially in high hazard, international, domains. In summary, the future of TC 9-5 is very bright. In a sense this is not all good news. It perhaps reflects the uncertain times in which we find ourselves.

The IFAC Coordinating Committee CC9 'Social Systems' offers a room of a great potential of research and technical developments, which will have a great impact in our society. Moreover, because the technology is advancing in the light speed, this CC has also the important role of influencing our control community, to think deeper about the further purposes and consequences of our works.