

Foreword

Control systems research has a long history of mathematical rigor, with application to diverse branches of science and engineering. The methods, algorithms, and tools developed by control researchers have been widely used by generations of engineers to solve problems of practical importance with enormous impact on society. Control concepts have been crucial in the design and development of high-performance airplanes, fuel-efficient automobiles, industrial process plants, manufacturing enterprises, smart phones, planetary rovers, communication networks, and many other applications across various sectors of industry. In these and other complex engineering systems, control theory and its technological artifacts are also widely used to ensure reliable, efficient, and cost-effective operations. The tremendous variety of control applications, however, makes it difficult for control technologists working in one domain to be aware of recent developments in other areas. It is even more difficult for researchers and decision makers outside the control discipline to fully appreciate the contributions that control technology has made to modern societies or its potential for future impact.

Funding agencies in the U.S., Europe, Japan, and Australia, among others, have invested in control systems research over the last 40 years. The funded research has partly been on fundamental questions and challenges such as robustness, stability, and adaptability, and partly on cross-disciplinary endeavors in areas such as complexity, wireless sensor networks, real-time systems and platforms, and cognitive systems. As with other branches of engineering and science, however, recent funding trends in control point toward applied rather than basic research and toward the pursuit of application challenges. The new model for research in the “Innovation Economy” targets collaborations between academia and industry on a global scale, where the competition for limited funding resources is on the rise.

The National Academy of Engineering in the United States has identified 14 grand challenges primarily dealing with energy, environment, transportation, and healthcare [1]. The European Commission’s R&D and innovation programs focus on similar objectives [2,3]. New developments in mathematical systems and control theory, algorithms, methods, and tools are needed to meet many of these challenges today and in the future. As a result, the control community is increasingly engaged in collaborative projects dealing with emerging concepts and themes—examples include cyber-physical systems and systems of systems—and in applications of these research fields in areas such as transportation networks and systems, medical devices, factories of the future, energy conservation and efficiency, and renewable energy integration for the power grid. For example, control systems researchers are teaming with computer scientists in using new hardware and software platforms to develop a new systems science addressing issues of sustainability, security, and cyber-enabled reconfiguration of engineering systems. In the last five years, radical developments have taken place in network science, a branch of complexity theory that seeks to establish universal laws and principles of networks, ranging from links between brain cells to the structure of the Internet [4]. Although their role is often unheralded, control engineers and scientists have been at the core of numerous innovations in this and other areas.

The Impact of Control Technology: Overview, Success Stories, and Research Challenges seeks to identify and recognize recent accomplishments in control systems research, to highlight new research directions and challenge problems for the field, and to communicate the contributions and potential of control within and beyond the boundaries of the discipline. In addition to articles reviewing the application of control in different domains and articles discussing new research frontiers, the report also includes a novel feature: 40-plus case studies, each in a graphical two-page format, illustrate “success stories” and “grand challenges” that will serve to enlighten and inspire the control community as well as its

stakeholders. The product of a unique outreach experiment, this report conveys the essential concepts, ideas, and impacts of the control discipline. *The Impact of Control Technology* is also an excellent example of international collaboration, and academic-industry collaboration, in the control field.

We consider this report a milestone for the promotion of control systems research. The content of the report argues strongly for the importance of control in preparing the next generation of scientists and engineers. This endeavor is of value to students and faculty, as well as to R&D leaders and decision makers in academia, industry, and government. In these challenging times of rapid technology developments and reduced funding for basic research, each research community needs to reinvent itself and make a compelling case to justify investment. In addition, by highlighting the impact of control on society, this report will be instrumental for outreach to the broader public.

The Impact of Control Technology articulates the value of control, for today and for the future. In this regard, the report is a unique document, and we hope it will serve as a foundation for further such efforts as well.

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