Preface

In the past two decades, scientists across diverse fields have been trying to identify the underlying mechanisms of networked systems. Biologists use networks to study the working and wiring of transcriptional regulatory circuits. Sociologists use networks to predict the behavior of techno-social systems. Physicists use networks to model and predict the emergence of behavior norms, and use quantitative methods to analyze the resulting networked systems. Across different fields, network scientists are making a dramatic progress and pushing network analysis to its limits. In engineering, researchers study how to assemble and coordinate individual physical devices into a coherent whole to perform a common task. This gives rise to a very active and exciting research field—multi-agent systems. With numerous civilian, homeland security, and military applications, multi-agent systems place high demands on features such as low cost, high adaptivity and scalability, increased flexibility, great robustness, and easy maintenance. To meet these demands, the current trend is to design distributed algorithms that rely on only local interaction to achieve global group behavior.

This book introduces emergent problems, models, and issues in distributed coordination of multi-agent networks. These problems, models, and issues represent some emergent research directions in the field of multi-agent systems. Emergent problems include collective periodic motion coordination, collective tracking with a dynamic leader, and containment control with multiple leaders. These problems extend the existing application domains of multi-agent networks. In particular, collective periodic motion coordination is appropriate for applications involving agent networks with repetitive movements, collective tracking guarantees tracking of a dynamic leader by multiple followers in the presence of reduced interaction and partial measurements, and containment control enables maneuvering of multiple followers by multiple leaders. Emergent models include networked Lagrangian systems and networked fractional-order systems. These models result from physical constraints or complex environments in which multi-agent systems operate. In particular, Lagrangian models represent a class of mechanical systems including autonomous vehicles, robotic manipulators, and walking robots, and fractional-order models are more realistic representations of systems operating in complex environments than integer-order models. Emergent issues include the sampled-data setting, optimality aspect, and time delay. These issues are realistic and important in real-world applications. In particular, the sampled-data setting is relevant when agents interact with their neighbors intermittently rather than continuously, the optimality aspect plays an important role in designing energy-efficient algorithms, and the time delay effect is inevitable in networked systems.

This book is divided into four parts. The first part introduces preliminaries (Chap. 1) and overviews recent research in distributed multi-agent coordination (Chap. 2). The second part introduces emergent problems in distributed multi-agent coordination, namely, collective periodic motion coordination (Chap. 3), collective tracking with a dynamic leader (Chap. 4), and containment control with multiple leaders (Chap. 5). The third part introduces emergent models in distributed multi-agent coordination, namely, networked Lagrangian systems (Chap. 6) and networked fractional-order systems (Chap. 7). The fourth part introduces emergent issues in distributed multi-agent coordination, namely, sampled-data setting (Chap. 8), optimality aspect (Chap. 9), and time delay (Chap. 10). We maintain a website http://www.neng.usu.edu/ece/faculty/wren/book/coordination at which can be found sample simulation and experimental videos and other useful materials associated with the book.

The results in this book would not have been possible without the efforts and support of our colleagues and students. In particular, we are indebted to Professors Randal Beard, Timothy McLain, Ella Atkins, Zongli Lin, Magnus Egerstedt, Zhihua Qu, Todd Moon, YangQuan Chen, and Yan Li for their constant support and professional inspirations. We also acknowledge all members of the Cooperative Vehicle Networks (COVEN) Laboratory at Utah State University, especially, Ziyang Meng, Jie Mei, and Fei Chen for their efforts. In particular, Ziyang Meng contributed to Chap. 10, Jie Mei contributed to Sect. 6.3, and Fei Chen contributed to Sect. 5.4. We are thankful to our editor Oliver Jackson for his interest in our project and his professionalism. In addition, we acknowledge IEEE, Elsevier, John Wiley & Sons, and Taylor & Francis for granting us the permission to reuse materials from our publications copyrighted by these publishers in this book. Finally, we gratefully acknowledge the support of our research on distributed multi-agent coordination by the National Science Foundation under CAREER Award ECCS–0748287, Computer Systems Research (CSR) Grant CNS–0834691, and Energy, Power, and Adaptive Systems (EPAS) Grant ECCS–1002393.

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Springer

http://www.springer.com/978-0-85729-168-4

Distributed Coordination of Multi-agent Networks
Emergent Problems, Models, and Issues
Ren, W.; Cao, Y.
2011, XVIII, 310 p., Hardcover
ISBN: 978-0-85729-168-4