Preface

Membrane computing is a vibrant and fast-growing research area of natural computation which covers the study of computing models, called membrane systems or P systems, inspired by the organization of the living cell and the biochemical reactions and phenomena occurring therein. The results obtained in this field have been published in comprehensive monographs covering theoretical aspects [4, 5] and applications in linguistics, graphics, computer science [1] and systems and synthetic biology [2]. The key research topics and further developments are overviewed in [3].

This book presents for the first time to the international community real-life complex and challenging applications modeled and analyzed with a membrane computing apparatus. These applications require different approaches and tools than those already investigated and described in the above-mentioned publications. They rely on a combination of different membrane systems and evolutionary or fuzzy reasoning methods, applied to a wide range of applications from various engineering areas, including engineering optimization, power systems fault diagnosis, mobile robots controller design, or complex biological systems involving data modeling and process interactions. This book goes far beyond the content of the Chinese textbook focusing mainly on applications of membrane computing [6] by addressing the basis of merging membrane computing concepts and evolutionary computing algorithms, by presenting a broader spectrum of real-life applications and the solid foundation of assessing the results and consequently targeting a much wider and diverse international audience.

The chapters covered in this monograph provide a clear image of the depth and breadth of the real-world applications of membrane systems.

– In Chap. 1, *Membrane Computing—Key Concepts and Definitions*: Basic membrane computing concepts that are used in the models presented in the next chapters are introduced. The most significant references to the research textbooks and overview papers are also provided.

- In Chap. 2, *Fundamentals of Evolutionary Computation*: Fundamental concepts and principles of evolutionary computation are addressed. Five variants of evolutionary computation techniques, including genetic algorithms, quantum-inspired evolutionary algorithms, ant colony optimization, particle swarm optimization and differential evolution, are discussed.
- In Chap. 3, *Membrane Algorithms*: Hybrid approximate optimization algorithms, called membrane algorithms or membrane-inspired evolutionary algorithms, integrating the hierarchical/network structure of P systems with meta-heuristic approaches are introduced and the design principles, their developments with key instances and examples are discussed. In addition, the impact of different variants of P systems with respect to membrane algorithms is analyzed.
- In Chap. 4, *Engineering Optimization with Membrane Algorithms*: A wide range of engineering applications of membrane algorithms with cell-like, tissue-like and neural-like P systems are discussed. The engineering problems include radar emitters signal analysis, digital image processing, controllers design, mobile robots path planning, constrained manufacturing parameters optimization problems, and distribution networks reconfiguration.
- In Chap. 5, *Electric Power System Fault Diagnosis with Membrane Systems*: Spiking neural P systems incorporating fuzzy logics are utilized to solve fault diagnosis problems of electric power systems. Definitions, reasoning algorithms and examples of fuzzy reasoning spiking neural P systems are presented.
- In Chap. 6, *Robot Control with Membrane Systems*: Numerical P systems and enzymatic numerical P systems are employed for designing membrane controllers for mobile robots. Simulators for numerical P systems and enzymatic numerical P systems modeling the robots' behavior are described and the results are analyzed.
- In Chap. 7, *Data Modeling with Membrane Systems: Applications to Real Ecosystems*: A bioinspired computing modeling paradigm within membrane computing, multienvironment P systems, is presented. This paradigm provides two different approaches (multicompartmental P systems and population dynamics P systems). The last approach is used to model population dynamics of real-world ecosystems. Ad hoc algorithms and simulators are introduced to simulate, analyze and (experimentally) validate population dynamics P systems.

This book will be of particular interest to researchers looking for applications of membrane computing, studying the interplay between membrane systems and other computational approaches and methods such as meta-heuristic optimization, fuzzy set theory and control theory. More generally, the book will be of interest to anyone studying bioinspired computing, engineering optimization, electric power systems fault diagnosis, robotics and ecosystems.

Finally, we would like to thank Gheorghe Păun for his continuous support in writing the book, as well as for many insightful comments and suggestions made. We are also very grateful to many colleagues, collaborators, Ph.D. students and friends for their helpful comments and discussions, especially to Jixiang Cheng,

Luis F. Macías-Ramos, Miguel A. Martínez-del-Amor, Agustín Riscos-Núñez, Luis Valencia-Cabrera, Tao Wang and Xueyuan Wang. Gexiang Zhang also acknowledges the support of his research activities provided by the National Natural Science Foundation of China (61170016, 61373047 and 61672437), the Research Project of Key Laboratory of Fluid and Power Machinery (Xihua University), Ministry of Education, P.R. China (JYBFX-YQ-1). We also thank the publisher for a friendly and efficient collaboration.

Chengdu, China — Gexiang Zhang
Sevilla, Spain — Mario J. Pérez-Jiménez
Bradford, UK — Marian Gheorghe

References

1. G. Ciobanu, M.J. Pérez-Jiménez, Gh. Păun (eds.), *Applications of Membrane Computing*, in Natural Computing Series (Springer, 2006)
2. P. Frisco, M. Gheorghe, M.J. Pérez-Jiménez (eds.), *Applications of Membrane Computing in Systems and Synthetic Biology*, in Emergence, Complexity and Computation Series (Springer, 2014)
3. M. Gheorghe, Gh. Păun, M.J. Pérez-Jiménez, G. Rozenberg, Research frontiers of membrane computing: open problems and research topics. *International Journal of Foundations of Computer Science* **24**, 5 (2013), 547–624.
4. Gh. Păun, *Membrane Computing—An Introduction* (Springer, 2002)
5. Gh. Păun, G. Rozenberg, A. Salomaa (eds.), *The Oxford Handbook of Membrane Computing* (Oxford University Press, 2010)
6. G. Zhang, J. Cheng, T. Wang, X. Wang, J. Zhu, *Membrane Computing: Theory & Applications* (Science Press, Beijing, China, 2015)

http://www.springer.com/978-3-319-55987-2

Real-life Applications with Membrane Computing

Zhang, G.; Pérez-Jiménez, M.J.; Gheorghe, M.

2017, XII, 355 p. 148 illus., 54 illus. in color., Hardcover
ISBN: 978-3-319-55987-2