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Preface

This special issue of Natural Computing contains papers in which the fundamental aspects of computational theory are applied to domains outside of the traditional, digital electronic realm. Researchers have taken inspiration from natural systems which are capable of leveraging the random motions and interactions of simple components to process information or to form complex structures, as exemplified in nature by the computations of biological networks or during the self-assembly of intricate crystalline structures. Using nature as an inspiration, researchers including the authors of the following papers have studied the theoretical limits of such systems, and generated road maps for the development of artificial systems with similar capabilities. These directions provide a fascinating blend of the abstract, mathematical theory of computation with the physical realities of natural and artificial systems, and offer the promise of novel and powerful future applications.

The origins of the International Conference on Unconventional Computation and Natural Computation (UCNC) go back to 1998, and from June 5-9, 2017, the 16th edition of the conference was held at the University of Arkansas, in Fayetteville, Arkansas, USA. The aim of UCNC is to bring together scientists from different backgrounds to present and discuss work related to novel forms of computation which are inspired by natural systems and which are outside of the realm of traditional computing. From among the wide diversity of interesting papers presented at the conference, a small group was selected for this special issue based on the strength of their reviews and the interest they inspired during the conference. The authors of these papers were invited to submit new, expanded versions of those papers to this issue, and these new versions underwent a second, independent review process. The selected papers—one concerning chemical reaction networks and three looking at self-assembly—include important expansions and improvements over the UCNC versions, and for that we are thankful to both the authors and the reviewers, who invested great efforts to ensure the correctness and quality of these papers.

In the paper "Real-time computability of real numbers by chemical reaction networks," Xiang Huang, Titus H. Klinge, James I. Lathrop, Xiaoyuan Li, and Jack Lutz explore the class of real numbers that can be computed by chemical reaction networks when their reaction rate constants are limited to integer values. They show not only that all algebraic numbers can be computed, but that some transcendental ones can be as well, and consider the links between this result and the long-standing Hartmanis-Stearns conjecture that irrational algebraic numbers are not real-time computable by Turing machine.

The paper "Self-Assembly of 4-sided Fractals in the Two-handed Tile Assembly Model," by Jacob Hendricks and Joseph Opseth, presents both a positive and a negative result about the power of a well-studied model of self-assembly, the 2-Handed Tile Assembly Model (2HAM). They first show that there are systems within the 2HAM capable of self-assembling any of a particular class of discrete self-similar fractals. They then show that for another class, no such systems can exist. These results provide important insights into the power of self-assembly in a hierarchical assembly model such as the 2HAM.

Austin Luchsinger, Robert Schweller, and Tim Wylie's paper, "Self-assembly of shapes at constant scale using repulsive forces," considers an extended version of the 2HAM in which both positive and negative interaction strengths are allowed, thereby allowing portions of an assembly to become unstable and detach. Their model allows them to construct arbitrary shapes using asymptotically optimal numbers of tile shapes and with $O(1)$ scale factor. This significantly improves on previous results in the field.

The final paper in this collection is "Verification in staged tile self-assembly" by Robert Schweller, Andrew Winslow, and Tim Wylie. They prove that the unique assembly and unique shape verification problems are both $\mathsf{coNP}^{\mathsf{NP}}$-hard and contained in PSPACE. In particular, they demonstrate that the unique shape verification problem in the 2HAM is $\mathsf{coNP}^{\mathsf{NP}}$-complete.

Since this is a special issue of Natural Computing consisting of select papers from UCNC 2017, we would first like to again thank everyone who helped to make UCNC 2017 a success, including the members of the Program Committee, the Steering Committee Co-Chairs, Nataša Jonoska and Jarkko Kari, and the members of the Organizing Committee - Cindy Pickney, Jamie Stafford, George Holmes, and Jason Crawley. Without their help, the conference couldn't have been successful and led to this special issue. We'd also like to thank the authors for accepting the invitation and providing greatly enhanced versions of their conference papers. For their great diligence and hard work in reviewing the included papers, we are especially indebted to the reviewers, Their work was instrumental in shaping and improving the papers. Finally, we thank the editors of Natural Computing who have given us direction and provided the necessary resources to put this issue together.

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