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Membrane Computing

19th International Conference, CMC 2018
Dresden, Germany, September 4–7, 2018
Revised Selected Papers

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Preface

The present volume contains the invited contributions and a selection of papers presented at the 19th International Conference on Membrane Computing (CMC 19), which was held in Dresden, Germany, during September 4–7, 2018 (further information can be found on the website at the following address: http://cmc19.uni-jena.de/) as well as one selected paper from the Workshop on Membrane Computing that was held in Fontainebleau, France, on June 25, 2018 (website address: https://ucnc2018.lacl.fr/wmc-ucnc-2018/) as a satellite event of the UCNC conference (Unconventional Computation and Natural Computation).

The CMC series started with three workshops that were organized in Curtea de Argeş, Romania, in 2000, 2001, and 2002. The workshops were then held in Tarragona, Spain (2003), Milan, Italy (2004), Vienna, Austria (2005), Leiden, The Netherlands (2006), Thessaloniki, Greece (2007), and in Edinburgh, UK (2008).

The tenth edition was organized again in Curtea de Argeş, in 2009, where it was decided to continue the series as the Conference on Membrane Computing (CMC). The following editions were held in Jena, Germany (2010), Fontainebleau, France (2011), Budapest, Hungary (2012), Chişinău, Moldova (2013), Prague, Czech Republic (2014), Valencia, Spain (2015), Milan, Italy (2016), and Bradford, UK (2017).

A regional version of CMC, the Asian Conference on Membrane Computing, ACMC, started in 2012 in Wuhan (China), and continued in Chengdu, China (2013), Coimbatore, India (2014), Hefei, Anhui, China (2015), Bangi, Selangor, Malaysia (2016), and Chengdu, (China), 2017.

CMC 19 was organized, under the auspices of the International Membrane Computing Society, by the Friedrich Schiller University of Jena, Germany.

The invited lectures were given by Erzsébet Csuhaj-Varjú (ELTE Eötvös Loránd University, Budapest, Hungary), Alberto Leporati (University Milan-Bicocca, Italy), Gheorghe Păun (Romanian Academy, Bucharest, Romania), Thomas Preußer (Accemic Technologies GmbH Dresden, Germany), and Stefan Schuster (Friedrich Schiller University Jena, Germany).

The Best Student Paper Award, sponsored by Springer, was given to the paper "Testing Identifiable Kernel P Systems Using an X-machine Approach," by Marian Gheorghe, Florentin Ipate, Raluca Lefticaru, and Ana Turlea.

The Best Paper Award was given to the paper "Solving QSAT in Sublinear Depth," by Alberto Leporati, Luca Manzoni, Giancarlo Mauri, Antonio E. Porreca, and Claudio Zandron.

The editors express their gratitude to the Program Committee, the invited speakers, the authors of the papers, the reviewers, and all the participants for their contributions to the success of CMC 19.

The support of the Friedrich Schiller University of Jena and the prize for the Best Student Paper award granted by Springer are gratefully acknowledged.

December 2018

Thomas Hinze
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Abstracts of Invited Papers

Membrane Computing, After Twenty Years (Extended Abstract)

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1 A Quick View over MC

The presentation will be a quick glimpse on the evolution of membrane computing, with an autobiographical character, starting with the initial motivation, briefly describing the main research directions, the bibliography, the dedicated meetings, the more active research groups.

A special attention is pais to the recently organized International Membrane Computing Society, its *Bulletin* (available at http://membranecomputing.net/IMCSBulletin/) and the forthcoming *Journal of Membrane Computing* (JMeC), to be published by Springer-Verlag (www.springer.com/41965, waiting for submissions at www.editorialmanager.com/JMEC).

Membrane computing is a research area (a branch of natural computing) aiming to abstract computing models from the structure and the functioning of the biological cell, considered alone or cooperating in tissues, colonies (e.g., of bacteria), organs (in particular, the brain). A large variety of models (called P systems) is obtained, most of them equivalent in power with the Turing machine; for many classes of P systems (especially, but not only when possibilities to create an exponential workspace in a polynomial time is provided, e.g., by means of cell division), then computationally hard problems (typically, **NP**-complete problems) can be solved in a feasible time (polynomial, or even linear). Several applications were reported (biology and bio-medicine, ecology, approximate optimization/distributed evolutionary computing, economics, linguistics, robot control and other technology issues, cryptography, computer graphics, and so on) and several software products were developed, including a dedicated programming language, *P-lingua*.

Three yearly dedicated international meetings are organized: *Conference on Membrane Computing - CMC* (from 2000 to 2009 it was called *Workshop on Membrane Computing WMC*, and from 2019 on *European CMC - ECMC*), the *Asian Conference on Membrane Computing - ACMC*, and the *Brainstorming Week on Membrane Computing - BWMC*. Also a *Workshop on Membrane Computing* started recently to be organized in China.

The bibliography of the domain is rather large: over 2500 papers, more than 100 PhD theses, about 10 monographs, about 50 collective volumes and special issues of journals – including the comprehensive *The Oxford Handbook of Membrane Computing*, OUP, 2010.

Although so developed, membrane computing is still an active research area, with many open problems and research directions waiting for further efforts. Among the branches of this kind, I mention here spiking neural P systems, numerical P systems, generalizations (such as kernel P systems), complexity issues, hypercomputation, membrane algorithms, software and implementation (e.g., on dedicated or on parallel existing hardware), applications in general - and especially in biology related areas.

2 Basic References in MC

A comprehensive source of information in MC is the website from http://ppage.psystems.eu hosted in Vienna, Austria: bibliographies, addresses of authors and groups, software, conferences, and so on. (Before it, a similar site was hosted in Milan, Italy, at http://psystems.disco.unimib.it.)

Here are a few **papers** (chronologically ordered) where various types of P systems were introduced:

1. Gh. Păun: Computing with Membranes. *Journal of Computer and System Sciences*, 61, 1 (2000), 108–143, and *Turku Center for Computer Science-TUCS Report* No 208, 1998 (www.tucs.fi).
2. Gh. Păun: P systems with active membranes: Attacking NP-complete problems, *J. Automata, Languages, and Combinatorics*, 6, 1 (2001), 75–90.
3. Andrei Păun, Gh. Păun: The power of communication: P systems with symport/antiport, *New Generation Computing*, 20, 3 (2002), 295–306.
4. Carlos Martín-Vide, Juan Pazos, Gh. Păun, Alfonso Rodriguez-Patón: Tissue P systems, *Theoretical Computer Sci.*, 296, 2 (2003), 295–326.
5. Gh. Păun, Radu Păun: Membrane computing and economics: Numerical P systems, *Fundamenta Informaticae*, 73, 1–2 (2006), 213–227.
6. Mihai Ionescu, Gh. Păun, Takashi Yokomori: Spiking neural P systems, *Fundamenta Informaticae*, 71, 2–3 (2006), 279–308.
7. Gh. Păun, Mario J. Pérez-Jiménez: Solving problems in a distributed way in membrane computing: dP systems, *Int. J. of Computers, Communication and Control*, 5, 2 (2010), 238–252.

I mention only these papers because I am involved in them and because they introduced solid research directions in MC; of course, there are several other research directions which deserve to be mentioned (similarly, they deserve to be mentioned the initiating papers), but the reader is referred to the MC bibliography for references: colonies, population, kernel, multi environment, polymorphic P systems, membrane algorithms, generalizations, arrays or other complex objects, formal verification and model checking, semantics and algebraic approaches, and so on and so forth.

Part of these issues can be found in the **monographs and collective volumes** in this area (including the massive handbook – number 5 below): I mention most of them – without conference volumes or special issues of journals devoted to MC:

1. Gh. Păun: *Membrane Computing. An Introduction*. Springer, 2002 (translated in Chinese in 2012).
2. Gabriel Ciobanu, Gh. Păun, M.J. Pérez-Jiménez, eds.: *Applications of Membrane Computing*. Springer, 2006.
3. Pierluigi Frisco: *Computing with Cells. Advances in Membrane Computing*. Oxford Univ. Press, 2009.
4. Gabriel Ciobanu: *Membrane Computing. Biologically Inspired Process Calculi*. The Publ. House of Al.I. Cuza Univ., Iaşi, 2010.
5. Gh. Păun, Grzegorz Rozenberg, Arto Salomaa, eds.: *The Oxford Handbook of Membrane Computing*. Oxford Univ. Press, 2010.
6. Vincenzo Manca: *Infobiotics. Information in Biotic Systems*. Springer, 2013.
7. Pierluigi Frisco, Marian Gheorghe, Mario J. Pérez-Jiménez, eds.: *Applications of Membrane Computing in Systems and Synthetic Biology*. Springer, 2014.
8. Gexiang Zhang, Jixiang Cheng, Tao Wang, Xueyuan Wang, Jie Zhu: *Membrane Computing: Theory and Applications.* Science Press, Beijing, 2015.
9. Gexiang Zhang, M.J. Pérez-Jiménez, M. Gheorghe: *Real-Life Applications with Membrane Computing*. Springer, 2017.
10. Andrei George Florea, Cătălin Buiu: *Membrane Computing for Distributed Control of Robotic Swarms: Emerging Research and Opportunities*, IGI Global, 2017.

Recent (hence comprehensive) bibliographies of several branches of MC as well as several lists of open problems can be found in the *Bulletin of IMCS*, at http://membranecomputing.net/IMCSBulletin/.

Algebra Meets Biology

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Abstract. Fibonacci numbers and the Golden Section occur in many instances in Biology. We have recently found that the potential number of fatty acids increases with their chain length according to the famous Fibonacci series, when *cis/trans* isomerism is neglected. Since the ratio of two consecutive Fibonacci numbers tends to the Golden section, 1.618…, organisms can increase fatty acid variability approximately by that factor per carbon atom invested. Moreover, we show that, under consideration of *cis/trans* isomerism, modification by hydroxy and/or oxo groups, triple bonds or adjacent double bonds, diversity can be described by generalized Fibonacci numbers (e.g. Pell numbers). Similar calculations can be applied to aliphatic amino acids. Our results should be of interest for mass spectrometry, combinatorial chemistry, synthetic biology, patent applications, use of fatty acids as biomarkers and the theory of evolution.

A second example of the role of algebra in biology discussed in this talk concerns intracellular calcium oscillations. Such oscillations are transformed (in a sense, decoded) in the cell by phosphorylation of proteins. In this way, an approximate temporal integral of the signal is computed. This implies that the number of spikes in the oscillation can be counted. In plant cells, an effect is often triggered only if a certain number of spikes (e.g., five) occurred. Some techniques for the mathematical modelling of such phenomena are reviewed here.

References

1. Schuster, S., Fichtner, M., Sasso, S.: Use of Fibonacci numbers in lipidomics – Enumerating various classes of fatty acids. Sci. Rep. **7**, 39821 (2017)
2. Fichtner, M., Voigt, K., Schuster, S.: The tip and hidden part of the iceberg: proteinogenic and non-proteinogenic aliphatic amino acids. Biochim. Biophys. Acta - Gen. Subj. **1861**, 3258–3269 (2017)
3. Bodenstein, C., Knoke, B., Marhl, M., Perc, M., Schuster, S.: Using Jensen's inequality to explain the role of regular calcium oscillations in protein activation. Phys. Biol. **7**, 036009 (2010)

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