On a Contribution of Membrane Computing to a Cultural Synthesis of Computer Science, Mathematics, and Biological Sciences

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Summary. Some topic contribution of membrane computing to a cultural synthesis of computer science, mathematics and biological sciences is presented.

1 Introduction

After a more than decade of the researches in the area of membrane computing, cf. [19], initiated by Gheorghe Păun it is worth to propose a discussion about a contribution of these researches to a cultural synthesis of computer science, mathematics, and biological sciences.

An aim of the present paper is to initiate the discussion focusing on these its aspects which are familiar to the author whose research area comprises mathematical foundations of computer science and foundations of mathematics itself.

The theme of the discussion was inspired by [11] and [2], where the goal of [11] is to propose a framework that should allow a healthy and positive role for speculations in mathematics although traditional mathematical norms discourage speculation whereas it is the fabric of theoretical physics. Thus a cultural synthesis of mathematics and theoretical physics is understood in [11] more or less explicitly as a mutual inspiration between the discussed areas.

We point out here that speculation in mathematics can be reinforced by computer experiments, cf. provocative article [10], which could extend the discussion in [11] to computer science with a regard to the relations between mathematical thinking and algorithmic thinking, cf. [12].

The responses in [2] contain various opinions about a role of speculation in mathematics from a defense of an importance of proofs, see S. Mac Lane's response continued in [14], to an acceptance of speculation as possessing equal rights to proofs. The response due to R. Thom in [2] suggests also a cultural synthesis of mathematics and biology.

We propose a looking forward approach to a cultural synthesis of the areas mentioned in the title of the present paper, where a cultural synthesis is also understood as mutual inspiration.

In the next section we outline some topic contribution of membrane computing to this cultural synthesis.

2 Topic contribution

We point out the following topics as a contribution of membrane computing to the discussed synthesis:

A) biologically inspired self-assembly (randomized, cf. [15] and [16]) P systems (with membrane division and creation) for solving NP complete problems, cf. [17] and [21], which extend algorithmic thinking by a new idea of a (randomized) algorithm for a construction of a self-assembly distributed system realizing massively parallel computation,
B) spiking neural P systems, cf. [18], with learning problem solution, cf. [9], which are a step towards digitalization[1] of neural networks within mathematical neuroscience, cf. e.g. [3],
C) fractal constructs generated by P systems, cf. [8], with P systems for obtaining homology groups, cf. [5], and a possibility to experiment with them (to predict some mathematical results like in [10] to be proved with mathematical precision like in [14]) via P-lingua programming environment designed in Seville, cf. [4] and [20].

Concerning A) one can ask for a relation of randomized P systems in [15] and randomized Gandy–Păun–Rozenberg machines [16] with probabilistic computing devices discussed in [1].

References

1. Arora, S., Barak, B., *Computational Complexity: A Modern Approach*, Cambridge Univ. Press, Cambridge, 2009.
2. Atiyah, M., et al., *Responses to* [11], Bull. Amer. Math. Soc. 30 (1994), pp. 178–207.
3. Bohte, S. M., *Spiking Neural Networks*, Professorschrift, Leiden University, 2003.
4. Díaz-Pernil, D., Pérez-Hurtado, I., Pérez-Jiménez, M. J., Riscos-Núñez, A., *A P-Lingua Programming Environment for Membrane Computing*, in: Membrane Computing, Lecture Notes in Computer Science 5391, Springer, Berlin, 2009, pp. 187–203.
5. Díaz-Pernil, D., Gutiérrez-Naranjo, M. A., Real, P., Sanchez-Canales, V., *A cellular way to obtain homology groups in binary 2D images*, in: Eight Brainstorming Week on Membrane Computing, Seville 2010, ed. M. A. Martinez-del-Amor et al., RGNC Report 01/2010, Seville University, pp. 89–99.

[1] in a similar way as cellular automata digitalize physics according to E. Fredkin, S. Wolfram, cf. [6], [7], [13]

6. Fredkin, E., *An introduction to digital philosophy*, Internat. J. Theor. Phys. 42 (2003), pp. 189–247.
7. Fredkin, E., *Digital mechanics*, Phys. D 45 (1990), pp. 254–270.
8. Gutiérrez-Naranjo, M. A., Pérez-Jiménez, M. J., *Fractals and P systems*, in: Fourth Brainstorming Week on Membrane Computing, Seville 2006, vol. II, ed. C. Graciani et al., Fenix Editora, 2006, pp. 65–86.
9. Gutiérrez-Naranjo, M. A., Pérez-Jiménez, M. J., *A spiking neural P systems based model for Hebbian learning*, in: Proceedings of 9th Workshop on Membrane Computing, Edinburgh, July 28 – July 31, 2008, ed. P. Frisco et al., Technical Report HW-MASC-TR-0061, School of Mathematical and Computer Sciences, Heriot–Watt University, Edinburgh, UK, 2008, pp. 189–207.
10. Horgan, J., *The death of proof*, Scientific American 269, no. 4 (October 1993), pp. 74–82.
11. Jaffe, A., Quinn, F., *Theoretical mathematics: Towards a cultural synthesis of mathematics and theoretical physics*, Bull. Amer. Math. Soc. 29 (1993), pp. 1–13,
12. Knuth, D. E., *Algorithmic thinking and mathematical thinking*, Amer. Math. Monthly 92 (1985), pp. 170–181.
13. Kůrka, P., *Topological and Symbolic Dynamics*, Société Mathématique de France, Paris, 2003.
14. S. Mac Lane, *Despite physicists, proof is essential in mathematics*, Synthese 111 (1997), pp. 147–154.
15. A. Obtułowicz, *Probabilistic P systems*, in: Membrane Computing, ed. Gh. Păun et al., Lecture Notes in Computer Science 2597, Springer, Berlin, 2003, pp. 377–387.
16. A. Obtułowicz, *Randomized Gandy–Păun–Rozenberg machines*, in: Membrane Computing, Lecture Notes in Computer Science 6501, Springer, Berlin, 2011, pp. 305–324.
17. Păun, Gh., *P systems with active membranes: Attacking NP complete problems*, Journal of Automata, Languages and Combinatorics 6 (2000), pp. 75–90.
18. Păun, Gh., Pérez-Jiménez, M. J., *Spiking neural P systems. Recent results, research topics*, presented at the 6th Brainstorming Week on Membrane Computing, Sevilla 2008, web page `http://psystems.disco.unimib.it/download/leidenGR65.pdf`
19. Păun, Gh., Rozenberg, G., Salomaa, A., *The Oxford Handbook of Membrane Computing*, Oxford, 2009.
20. The P-Lingua website, `http://www.p-lingua.org`
21. Zandron, C., Ferretti, C., Mauri, G., *Solving NP complete problems with active membranes*, in: Unconventional Models of Computation, UMC'2K, ed. I. Antoniu et al., Berlin, 2001, pp. 289–301.