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FOREWORD

"Second Brainstorming week on Membrane Computing" in Sevilla 2004

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The present volume contains a selection of papers elaborated during the "Second Brainstorming Week on Membrane Computing", held in Sevilla, Spain, from February 2 to February 7, 2004, in the organization of the Research Group on Natural Computing (RGNC) from the Department of Computer Science and Artificial Intelligence of Sevilla University. The first edition of this series of meetings of a novel type was held in Tarragona, in February 2003, and the goal is to gather together a number of active researchers in membrane computing, for exchanging ideas, presenting recent results, and working together for one week in an informal and friendly environment.

The efficiency of such meetings is obvious, this year the success being still higher than the previous year. In total, 38 researchers from various countries were present in Sevilla, many of them young computer scientists, and a large number of research topics, problems, preliminary results were discussed and then turned out into papers. The initial versions of these papers were collected in a proceedings volume which was published as a technical report (no 1/2004) of RGNC, Sevilla University; the volume, of about 460 pages, is available also through the web page from `http://psystems.disco.unimib.it`.

Part of these papers, continued after the Brainstorming, further polished and additionally refereed, are included in this volume; another series of papers were selected for a special issue of *Journal of Universal Computer Science*.

Very shortly stated, membrane computing is a branch of natural computing whose aim is to abstract a computing model from the structure and the functioning of the living cell. Basically, a membrane system (P system) is a distributed parallel computing model, where multisets of symbol-objects are processed in the compartments defined by a cell-like hierarchy of membranes. These objects evolve by means of multiset rewriting-like rules and/or by communication rules (such as symport/antiport rules) which are applied in a maximally parallel (all objects which can evolve should do it) non-deterministic (the objects to process and the rules to apply are chosen in a random way) manner. There are many classes of P systems, with biological or mathematical motivation. For instance, the objects can be also strings of symbols, the membrane structure can be described by a graph (the so-called tissue P systems), or can itself evolve, e.g., by membrane dissolution and membrane division. Most of these types of systems were proven to be computationally universal, equivalent in power to Turing machines. In cases where an exponential space can be created in a polynomial time – for instance, by means of biologically well motivated operations, such as membrane division or membrane creation – by trading space for time one can solve computationally hard problems (typically, **NP**-complete problems) in polynomial (often, linear) time. In the last years, membrane computing also started to be used as a framework for modelling various biological phenomena, mainly at the cell level, as well as a toolkit for applications in linguistics, computer graphics, management, etc.

A comprehensive presentation of the domain, at the level of the spring of 2002, can be found in the monograph Gh. Păun, *Membrane Computing. An Introduction*, Springer-Verlag, Berlin, 2002, while the current bibliography of membrane computing (including many downloadable papers) can be found at the above mentioned web page.

The papers which follow illustrate both one of the general trends of membrane computing – to constantly look to the biology of the cell in order to get inspiration for new mathematical developments – and two main classes of research topics and results – computational

G. Păun · M. J. Pérez-Jiménez
Universidad de Sevilla
ETS Ingenieria Informatica
Depto. Informatica e Inteligencia
Artificial
Avenida Reina Mercedes,s/n
41012 Sevilla SPANIEN
E-mail: gpaun@us.es

power (universality) and solving computationally hard problems in a feasible time.

Actually, the first five papers are mainly concerned with the computational power of membrane systems. In the first paper, directly inspired by biological facts, I.I. Ardelean et al. consider P systems where computations are controlled by signals which move across the regions. The minimal amount of resources to get the universality of different types of P systems are studied by F. Bernardini and M. Gheorghe (for tissue P systems where communication rules are inspired by the general mechanism of cell communication based on signal receptors), by D. Besozzi et al. (who, again starting from biological observations, consider P systems where new membranes can be produced, through the so-called process of gemmation), by R. Freund and A. Păun (for P systems with active membranes and string-objects, without using electrical charges), and by P. Frisco (for P systems with minimal symport/antiport).

The last three papers are devoted to the computational efficiency of P systems. They provide efficient solution to three well-known **NP**-complete problems: the Partition problem (by M.A. Gutiérrez et al., using recognizer P systems with active membranes), the Shortest Common Superstring problem (by L. Ledesma et al., using a variant of tissue P systems), and the Satisfiability problem (L. Pan et al., using a variant of P systems with active membranes where new types of operations with membranes are allowed, such as the biologically inspired one of separation).

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Gheorghe Păun
Mario J. Pérez-Jiménez
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