Natural computing paradigm and applications

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Natural computing is not a new paradigm in computer science. It covers nowadays many models using different computational instruments and aiming at solving a large variety of problems. Genetic programming and algorithms, neural computing, evolutionary computing and programming, cellular automata and L-systems are among the most established fields of natural computing. Genetic algorithms will be utilised in one of the papers of this volume to devise metaheuristic search techniques in a specialised testing environment.

In the last 10 years a number of new computational paradigms have emerged, either inspired by or to account for, the multifaceted complex phenomena present in biological processes. DNA and membrane computing, networks of evolutionary processes, amorphous computing, swarm intelligence algorithms, artificial immune systems are some of the most recent developments in this area. *Membrane computing*, also known as P systems, introduced by [1] (see [2] for a modern introduction), formally captures various mechanisms present in cells and includes several of its most fundamental features through computability and formal language theoretic constructs. Although young, membrane computing is a vigorous research field having a relevant impact on a variety of disciplines. Indeed, P systems research is growing fast: in 2003 the *Thompson Institute for Scientific Information* characterised the initial paper [1] as "fast breaking" and the domain as "emergent research front in computer science". Since 2000 several volumes and a large number of papers have appeared reporting on the scientific progress accounting for a wealth of solid theoretical investigations as well as very promising applications. In this volume both these aspects will be covered.

Computational models associated with various formal methods are intensively applied in areas that represent a very fertile source of inspiration for natural computing, namely biology, chemistry. State based models are among the most popular in this respect, due to their simplicity in design and implementation and their strong connections to the field of formal verification and testing. One such mechanism, largely utilised in software engineering for specifying, implementing and testing complex software systems and called X-machines, is also very successfully employed to model biological systems, fact illustrated by some of the papers included in the volume.

The goal of this special issue is to collect a number of papers describing a variety of aspects in natural computing or in using computational models to formally specify

the behaviour of some biological systems. Finally, fundamental aspects regarding the formal definition of some computer science concepts are presented. The papers are sumarised below.

Genetic Model based Testing: a Framework and a Case Study, by F. Ipate and R. Lefticaru, focuses on building a graph-based model of a given specification, by using an evolutionary approach based on genetic algorithms and then, using the same mechanisms a test set is generated.

D. Díaz–Pernil, M.J. Pérez–Jiménez, A. Riscos–Núñez and A. Romero–Jiménez in *Computational Efficiency of Cellular Division in Tissue-like Membrane Systems*, investigate a special class of P systems, called uniform tissue-like P systems with cell division, with respect to their ability to provide a uniform linear–time solution for the NP–complete `Vertex Cover` problem.

Sorting with P systems: A Biological Perspective by I.I. Ardelean, R. Ceterchi and A.I. Tomescu, provide a set of efficient primitives to simulate sorting operations, inspired by communication processes occurring in biological membranes of bacteria.

A Paradigm for Self-organisation: New Inspiration from Ant Foraging Trails by D. E. Jackson, M. Bicak and M. Holcombe, presents a thorough introspection into the behaviour of Pharaoh's ants. It provides, for some of the related problems, an agent based model using the X-machine as a computational paradigm and suggests some ways to devise new ant algorithms able to tackle problems of autonomic and autonomous systems.

I. Stamatopoulou, I. Sakellariou, P. Kefalas and G. Eleftherakis in *OPERAS for Social Insects: Formal Modelling and Prototype Simulation* describe a new formalism that brings together features regarding X-machines and P systems in order to obtain a more flexible agent based specification language.

G. Ciobanu and D. Rusu in *Synchronizing the Shared Resources* describe a special algebra, called "synchronizing resource algebra", enriched with some supermetrics, in order to express synchronization features of some concurrent processes.

The topics of the papers from this special issue give us the opportunity to mark Professor Tudor Bălănescu's longstanding valuable scientific activity, with contributions to various fields of computer science, ranging from the theory of programming languages, to their design and implementation, and including aspects of natural computing and the use of the X-machine model for testing purposes. We would like to wish him a long and fruitful research career, at his 60th birthday which occurred in December 2007.

References

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