Introduction

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The Eighth International Conference on Unconventional Computation (UC 2009) was held in Ponta Delgada, Portugal, on São Miguel Island in the Archipelago of the Azores, during the week of September 7–11, 2009. The meeting was organized under the auspices of the European Association for Theoretical Computer Science (EATCS) by the University of Azores (Ponta Delgada, Portugal) and the Centre for Discrete Mathematics and Theoretical Computer Science (Auckland, New Zealand). The venue was the University of Azores, with its modern and well-equipped auditoria, next to the magnificent rectory, and surrounded by a most pleasant and peaceful garden.

São Miguel is famous for its beautiful landscapes and exceptional volcanic lakes. Depending on the surrounding countryside, some lakes appear peaceful and relaxing, while others are quite dramatic. Ponta Delgada has many magnificent buildings of great architectural value, portraying the urban construction of the sixteenth to nineteenth centuries. The majority of these are currently used to accommodate various political, administrative, religious, and cultural offices. There are several churches that are veritable works of art, with Gothic structures and Manueline exteriors. Others are in the baroque style, with interiors embroidered in gold thread and with rare wood furniture pieces. Famous paintings are also easily found in Ponta Delgada.

The International Conference on Unconventional Computation (UC) series is devoted to all aspects of unconventional computation— theory, as well as experiments and applications. (See `https://www.cs.auckland.ac.nz/CDMTCS/conferences/uc`.) Typical, topics have been: natural computing (including quantum, cellular, molecular, membrane, neural, and evolutionary paradigms), as well as chaotic and dynamical system-based computing and various proposals for computational mechanisms that go beyond the Turing model.

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Papers were solicited from among the conference presentations, as suggested by the chairpeople of sessions and by the editors. Some additional authors with

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relevant contributions to the field were also invited to round out this special issue of *Natural Computing* devoted to unconventional computation.

After reviewing, nine papers were included in this special issue. These are the following:

- *Greedy versus social: Resource-competing oscillator network as a model of amoeba-based neurocomputer*, by Masashi Aono, Yoshito Hirata, Masahiko Hara, and Kazuyuki Aihara

  A single-celled amoeboid organism, Physarum polycephalum, exhibits rich spatio-temporal oscillatory behavior and sophisticated computational capabilities. Considering the organism as a network of oscillators that compete for limited amounts of intracellular resources, the authors formulate an ordinary differential equation model of the amoeba-based computer. The aim is to clarify how the organism achieves "overall optimisation," the maximisation of benefit of the whole body, which cannot always be realised by simply summing selfish behaviours of the organism's components pursuing their partial interests.

- *Unconventional complexity measures for unconventional computers*, by Ed Blakey

  The tried and tested methods of quantifying the efficiency of conventional computers often fail in the context of unconventional (e.g., quantum, DNA, or analogue) computing. The problem is one of computational resources: new computational models may consume new resources, with a corresponding need for new complexity measures. The paper discusses various non-standard resources (and various interpretations of the term "resource" itself), advocating such resources' consideration when analysing the complexity of unconventional computers.

- *Abstract geometrical computation* 5*: Embedding computable analysis*, by Jérôme Durand-Lose

  This paper relates functions over real numbers and purely geometrical constructions. Any computable function over real numbers (effectively convergent sequences of rational numbers) can be embedded as the limit of an automatic drawing. These drawings result from moving signals that are replaced upon collision.

- *On the hierarchy of conservation laws in a cellular automaton*, by Enrico Formenti, Jarkko Kari, and Siamak Taati

  Conservation laws in cellular automata are studied as an abstraction of the conservation laws observed in nature. In addition to the usual real-valued conservation laws, the paper also considers more general group-valued and semigroup-valued conservation laws. It is proved that it is undecidable whether a given one-dimensional cellular automata has any real valued

non-trivial conservation laws, while for two- and higher-dimensional automata, it is undecidable even whether a given semi-group valuation is conserved. For one-dimensional automata, one can effectively construct the most general conservation law for any given fixed interaction range. Some interconnections between the structure of the hierarchy of conservation laws and the dynamical properties of the automata are emphasised.

- *Computability in planar dynamical systems*, by Daniel Graça and Ning Zhong

  This paper studies the computability of long-term behaviour of systems defined on the plane. It is shown that computability and stability are deeply related: highly non-stable systems engender highly non-computable long-term properties.

- *Distributed Quantum Programming*, by Ellie D'Hondt and Yves Vandriessche

  The authors explore the structure and applicability of the Distributed Measurement Calculus, a low-level assembly language for quantum computations. They describe the language's syntax and semantics, and state several properties that are crucial to the practical usability of the language, such as compositionality and context-freeness. The language developed is used as the basis for a virtual machine for distributed quantum computations. Programs are expressed using the syntax of the calculus and executed by the rules of its semantics. However, the virtual machine is much more than a simple translation thereof, as it needs to evaluate programs automatically, while at the same time dealing with memory management, parameter passing, and the like. By virtue of such a virtual machine, program execution no longer needs to be analysed or executed by hand. Graphical and composition techniques for program specification are given, to provide an expressive and user-friendly quantum programming environment.

- *Influences on the formation and evolution of Physarum polycephalum inspired emergent transport networks*, by Jeff Jones

  The giant single-celled organism, the true slime mould, Physarum polycephalum, has been the subject of recent research in distributed computation due to its ability to solve complex spatial problems using only simple component parts. This work investigates the behaviour of a virtual slime mould-like material that spontaneously forms complex and emergent transport networks from simple swarm-based collective behaviour, considering both local and global influences on the evolution of the networks.

- *Quantum value indefiniteness*, by Karl Svozil

  The indeterministic outcome of a measurement of an individual quantum is certified by the impossibility of the simultaneous, unique, definite,

deterministic pre-existence of all conceivable observables from physical conditions of that quantum alone.

- *Unwinding performance and power on Colossus, an unconventional computer*, by Benjamin Wells

  In 1944, the computing machine known as Colossus began supporting British cryptanalysis of German High Command wireless traffic, nicknamed Tunny. Colossus was largely responsible for the decryption of 63 million Tunny characters. This first electronic digital and very unconventional computer was not a stored-program general purpose machine in today's terms. Nonetheless, a universal Turing machine could have been implemented on the ten Colossi installed at Bletchley Park. Therefore, it was as powerful a computer as today's laptop or mainframe, or any future computer of this type.

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