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Natural and Artificial Models in Computation and Biology

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Preface

Living Nature Computing

A trend in computing is the disappearing computer, that is, computers become part of the environment, part of our daily lives, sharing our personal spaces, our amusements, even our own bodies - e.g., embedded systems, accompanying robotics, electronic neuroprosthetics. This implies that computing will also become part of living nature and that computing will be performed by living nature. We believe it is essential to articulate the relationship between different areas of science in order to collaborate and foster a discussion on the interplay of computing with living natural systems.

Natural computing has two sides: computing inspired by nature and computing in nature. These two sides are usually seen as complementary, but our meeting is situated at the intersection/interplay of these two sides. We call this intersection “Living Nature Computing.” The term living nature should be taken in a broad sense: from cells via animals to humans. Living nature also puts a focus on natural computing: evolutionary computing and neural networks are examples of natural computing inspired by living nature. DNA computing is included as far as the computation takes place inside living nature. A further focus is the type of computation: we consider engineered computation as inspired by living nature.

Six interesting areas are selected, which share aspects of living nature computing, that we would like to promote in our meetings.

- Cognitive Robotics: Cognitive robotic systems, apart from being practical engineering challenges, are also excellent platforms for experimenting with situated and embodied cognitive theories and models, posing interesting and hard challenges to theoretical and fundamental cognition issues. As Prof. Mira said: “Robotics is the most complete paradigm in Artificial Intelligence: it includes, perception, reasoning, and action.”
- Natural Computing: Natural computing refers to computational processes observed in nature, and to human-designed computing inspired by nature. When complex natural phenomena are analyzed in terms of computational processes, our understanding of both nature and the essence of computation is enhanced. Characteristic of human-designed computing inspired by nature is the metaphorical use of concepts, principles, and mechanisms underlying natural systems. Natural computing includes evolutionary algorithms, neural networks, molecular computing, quantum computing, neural modelling, plasticity studies, etc.
- Wetware computation: Wetware computation refers to an organic computer built from living neurons. Silicon-based microchips have physical limits and also power dissipation problems. Wetware computing uses biochemistry

instead of silicon for finding better solutions to be used in future electronics and in information and communications technologies. Molecules or living organisms may carry electrical charge and may perform computing functions with less integration or power dissipation. A wetware computer may be built from leech neurons and be capable of performing simple arithmetic operations and simple pattern-recognition tasks. Another wetware computation is based on cellular cultures. Cells could be neurons from dissociated hippocampus or cortical tissue, neuroblastoma cells, or even PC12 cells, a cell line derived from the rat adrenal medulla.

- Quality of Life Technologies: During the last few years, there is an increasing interest in technologies oriented to improve the quality of life of people. Quality of life technologies (QoLTs) cover a broad area of research including engineering, computer science, medicine, psychology, or social sciences. Typical applications of QoLTs include assistance technologies for people with some kind of disability as, for example, assistive robots, elderly care technologies, or smart homes. However, QoLTs include powerful tools to improve the well-being of individuals and societies in general.
- Biomedical and Industrial Perception Applications: Image understanding is a research area involving both feature extraction and object identification within images from a scene, and a posterior treatment of this information in order to establish relationships between these objects with a specific goal. In biomedical and industrial scenarios, the main purpose of this discipline is, given a visual problem, to manage all aspects of prior knowledge, from study start-up and initiation through data collection, quality control, expert independent interpretation, to the design and development of systems involving image processing capable of tackle with these tasks.
- Web Intelligence and Neuroscience: The study of a user's brainwaves applied to reveal the impact of personalized Web content opens the door for powerful collaborations between Web intelligence and neuroscience. The purpose of this area is to discuss the potential applications of neuroscience methods and concepts in order to evaluate, design, and develop user satisfaction models for intelligent websites. Some of the potential research areas to be analyzed are personalization of Web content and Web application design. On the basis of empirical recordings, it is possible to reveal which features are relevant for each user, therefore learning how to personalize both content and business logic in order to improve the overall user satisfaction. Brainwave analysis can provide the mechanisms to record and measure relevant user behavior patterns regarding memory, attention, and other cognitive aspects. The data obtained by brainwave analysis could guide the development of user satisfaction models, i.e., conceptual and mathematical models that could explain not only why users are satisfied with the provided content, but also predict future satisfaction.

We want to study living nature computing using a systems approach. Computing is not an add-on to the living system, but it is an integral part that is in symbiosis with the system. In fact, it is often not possible to distinguish the

computational parts from the non computational parts. This wider view of the computational paradigm gives us more elbow room to accommodate the results of the interplay between nature and computation. The IWINAC forum thus becomes a methodological approximation (set of intentions, questions, experiments, models, algorithms, mechanisms, explanation procedures, and engineering and computational methods) to the natural and artificial perspectives of the mind embodiment problem, both in humans and in artifacts. This is the philosophy of IWINAC meetings, the “interplay” movement between the natural and the artificial, facing this same problem every two years. This synergistic approach will permit us not only to build new computational systems based on the natural measurable phenomena, but also to understand many of the observable behaviors inherent to natural systems.

The difficulty of building bridges between natural and artificial computation is one of the main motivations for the organization of IWINAC 2013. The IWINAC 2013 proceedings contain the works selected by the Scientific Committee from more than 100 submissions, after the refereeing process. The first volume, entitled *Natural and Artificial Models in Computation and Biology*, includes all the contributions mainly related to the methodological, conceptual, formal, and experimental developments in the fields of neurophysiology and cognitive science. The second volume, entitled *Natural and Artificial Computation in Engineering and Medical Applications*, contains the papers related to bioinspired programming strategies and all the contributions related to the computational solutions to engineering problems in different application domains, especially health applications, including the CYTED “Artificial and Natural Computation for Health” (CANS) research network papers.

An event of the nature of IWINAC 2013 cannot be organized without the collaboration of a group of institutions and people who we would like to thank now, starting with *UNED* and *Universidad Politécnica de Cartagena*. The collaboration of the *UNED Associated Center in Palma de Mallorca* was crucial, as was the efficient work of the Local Organizing Committee, Miguel Angel Vázquez Segura, and Francisco J. Perales López with the close collaboration of the *Universitat de les Illes Balears*. In addition to our universities, we received financial support from the Spanish *CYTED*, *Red Nacional en Computación Naturalmente Artificial* and *Apliquem Microones 21 s.l.*

We want to express our gratefulness to our invited speakers, Rodolfo Llinás, from the Department of Physiology and Neuroscience at New York University, Dario Floreano, from the Laboratory of Intelligent Systems at EPFL (Switzerland), and Pedro Gómez-Vilda, from the Oral Communication Lab “Robert Wayne Neucomb” in UPM (Spain), for accepting our invitation and for their magnificent plenary talks.

We would also like to thank the authors for their interest in our call and the effort in preparing the papers, condition sine qua non for these proceedings. We thank the Scientific and Organizing Committees, in particular the members of these committees who acted as effective and efficient referees and as promoters

and managers of pre organized sessions on autonomous and relevant topics under the IWINAC global scope.

Our sincere gratitude goes also to Springer and to Alfred Hofmann and his collaborators, Anna Kramer and Elke Werner, for the continuous receptivity, help efforts, and collaboration in all our joint editorial ventures on the interplay between neuroscience and computation.

Finally, we want to express our special thanks to ESOC, our technical secretariat, and to Victoria Ramos and Nuria Pastor, for making this meeting possible, and for arranging all the details that comprise the organization of this kind of event.

All the authors of papers in this volume, as well as the IWINAC Program and Organizing Committees, would like to commemorate the memory of Professor Mira, who passed away five years ago, both as a great scientist, with an incredible dissemination profile, and as best friend. We still carry his memory deep inside our hearts.

June 2013

José Manuel Ferrández Vicente
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