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# Artificial Intelligence and Knowledge Engineering Applications: A Bioinspired Approach

First International Work-Conference on the Interplay  
Between Natural and Artificial Computation, IWINAC 2005  
Las Palmas, Canary Islands, Spain, June 15-18, 2005  
Proceedings, Part II



Springer

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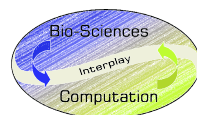
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# In Search of Mechanisms, Symbols, and Models underlying Cognition

**International Work-conference on the Interplay  
between Natural and Artificial Computation, IWINAC2005  
Las Palmas de Gran Canaria, Spain, June 2005  
Proceedings, Part I**

Lecture Notes in Computer Science



[...]

Volume Editors

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[...]

# Preface

The computational paradigm considered here is a conceptual, theoretical and formal framework situated above machines and living creatures (two instantiations), sufficiently solid, and still non-exclusive, that allows us:

1. to help neuroscientists to formulate intentions, questions, experiments, methods and explanation mechanisms assuming that neural circuits are the psychological support of calculus;
2. to help scientists and engineers from the fields of artificial intelligence (AI) and knowledge engineering (KE) to model, formalize and program the computable part of human knowledge;
3. to establish an interaction framework between natural system computation (NSC) and artificial system computation (ASC) in both directions, from ASC to NSC (in computational neuroscience), and from NSC to ASC (in bioinspired computation).

With these global purposes, we organized IWINAC 2005, the 1st International Work Conference on the Interplay Between Natural and Artificial Computation, which took place in Las Palmas de Gran Canaria, Canary Islands (Spain), during June 15–18, 2005, trying to contribute to both directions of the interplay:

- I:** From Artificial to Natural Computation. What can computation, artificial intelligence (AI) and knowledge engineering (KE) contribute to the understanding of the nervous system, cognitive processes and social behavior? This is the scope of computational neuroscience and cognition, which uses the computational paradigm to model and improve our understanding of natural science.
- II:** From Natural Sciences to Computation, AI and KE. How can computation, AI and KE find inspiration in the behavior and internal functioning of physical, biological and social systems to conceive, develop and build up new concepts, materials, mechanisms and algorithms of potential value in real-world applications? This is the scope of the new bionics, known as bioinspired engineering and computation, as well as of natural computing.

To address the two questions posed in the scope of IWINAC 2005, we made use of the “building of and for knowledge” concepts that distinguish three levels of description in each calculus: the physical level (PL), where the hardware lives, the symbol level (SL) where the programs live, and a third level, introduced by Newell and Marr, situated above the symbol level and named by Newell as “the knowledge level” (KL) and by Marr as the level of “the theory of calculus.” We seek the interplay between the natural and the artificial at each one of these three levels (PL, SL, KL).

1. For the interplay at the **physical level** we consider:

- **Computational Neuroscience.** *Tools:* Conceptual, formal and computational tools and methods in the modelling of neuronal processes and neural nets: individual and collective dynamics. *Mechanisms:* Computational modelling of neural mechanisms at the architectural level: oscillatory/regulatory feedback loops, lateral inhibition, reflex arches, connectivity and signal routing networks, distributed central-patterns generators. Contributions to the library of neural circuitry. *Plasticity:* Models of memory, adaptation, learning and other plasticity phenomena. Mechanisms of reinforcement, self-organization, anatomo-physiological coordination and structural coupling.
- **Bio-inspired Circuits and Mechanisms.** *Electronics:* Bio-inspired electronics and computer architectures. Advanced models for ANN. Evolvable hardware (CPLDs, FPGAs, etc.). Adaptive cellular automata. Redundancy, parallelism and fault-tolerant computation. Retinotopic organizations. *Non-conventional (Natural) Computation:* Biomaterials for computational systems. DNA, cellular and membrane computing. *Sensory and Motor Prostheses:* Signal processing, artificial cochlea, audio-tactile vision substitution. Artificial sensory and motor systems for hand-icapped people. Intersensory transfer and sensory plasticity.

2. For the interplay at the **symbol level** we consider:

- **Neuro-informatics.** *Symbols:* From neurons to neurophysiological symbols (regularities, synchronization, resonance, dynamics binding and other potential mechanisms underlying neural coding). Neural data structures and neural “algorithms.” *Brain Databases:* Neural data analysis, integration and sharing. Standardization, construction and use of databases in neuroscience and cognition. *Neurosimulators:* Development and use of biologically oriented neurosimulators. Contributions to the understanding of the relationships between structure and function in biology.
- **Bio-inspired Programming Strategies.** *Behavior-Based Computational Methods:* Reactive mechanisms. Self-organizing optimization. Collective emergent behavior (ant colonies). Ethology and artificial life. *Evolutionary Computation:* Genetic algorithms, evolutionary strategies, evolutionary programming and genetic programming. Macroevolution and the interplay between evolution and learning. *Hybrid Approaches:* Neuro-symbolic integration. Knowledge-based ANN and connectionist KBS. Neuro-fuzzy systems. Hybrid adaptation and learning at the symbol level.

3. For the Interplay at the **knowledge level** we consider:

- **Computational Approaches to Cognition.** *AI and KE:* Use of AI and KE concepts, tools and methods in the modelling of mental processes and behavior. Contribution to the AI debate on paradigms for knowledge representation and use: symbolic (representational), connectionist, situated, and hybrid. *Controversies:* Open questions and controversies in

AI and Cognition (semantics versus syntax, knowledge as mechanisms that know, cognition without computation, etc.). Minsky, Simon, Newell, Marr, Searle, Maturana, Clancey, Brooks, Pylyshyn, Fodor, and others. *Knowledge Modelling*: Reusability of components in knowledge modelling (libraries of tasks, methods, inferences and roles). Ontologies (generic, domain-specific, object-oriented, methods and tasks). Knowledge representation methodologies and knowledge edition tools.

- **Cognitive Inspiration in AI and KE.** *Synthetic Cognition*: Bio-inspired modelling of cognitive tasks. Perception, decision-making, planning and control. Biologically plausible (user-sensitive) man-machine interfaces. Natural language programming attempts. Social organizations, distributed AI, and multi-agent systems. *Bio-inspired Solutions to Engineering, Computational and Social Problems in Different Application Domains*: Medicine, image understanding, KBSs and ANNs for diagnoses, therapy planning, and patient follow-up. Telemedicine. Robotic paradigms. Dynamic vision. Path planning, map building, and behavior-based navigation methods. Anthropomorphic robots. Health biotechnology. Bio-inspired solutions for sustainable growth and development.

IWINAC 2005 was organized by the Universidad Nacional de Educación a Distancia (UNED) in cooperation with the Instituto Universitario de Ciencias y Tecnologías Cibernéticas de la Universidad de Las Palmas de Gran Canaria and the Las Palmas UNED Associated Center.

Sponsorship was obtained from the Spanish Ministerio de Ciencia y Tecnología and the organizing universities (UNED and Las Palmas de Gran Canaria).

The chapters of these two books of proceedings correspond to the talks delivered at the IWINAC 2005 conference. After the refereeing process, 117 papers were accepted for oral or poster presentation, according to the authors' preferences. We organized these papers into two volumes basically following the topics list previously mentioned. The first volume, entitled "*In Search of Mechanisms, Symbols, and Models Underlying Cognition*," includes all the contributions mainly related to the methodological, conceptual, formal, and experimental developments in the fields of neurophysiology and cognitive science.

In the second volume, "*Artificial Intelligence and Knowledge Engineering Applications: A Bioinspired Approach*," we have collected the papers related to bioinspired programming strategies and all the contributions related to the computational solutions to engineering problems in different application domains.

And now is the time for acknowledgements. A task like this, organizing a work conference with a well-defined scope, cannot be achieved without the active engagement of a broad set of colleagues who share with us the conference principles, foundations and objectives. First, let me express my sincere gratitude to all 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 preorganized sessions on autonomous and relevant topics under the IWINAC global scope. Thanks also to the invited speakers, Joost N. Kok,



Dana Ballard and Juan Vicente Sánchez Andrés, for synthesizing the plenary lectures. Finally, thanks to all the authors for their interest in our call and their efforts in preparing the papers, condition sine qua non for these proceedings.

My debt of gratitude to José Ramón Álvarez and Félix de la Paz goes further the frontiers of a preface. Without their collaboration IWINAC 2005 would not have been possible, in the strictest sense. And the same is true concerning Springer and Alfred Hofmann, for being continuously receptive and for collaborating on all our editorial joint ventures on the interplay between neuroscience and computation, from the first IWANN in Granada (1991, LNCS 540), to the successive meetings in Sitges (1993, LNCS 686), Torremolinos (1995, LNCS 930), Lanzarote (1997, LNCS 1240), Alicante (1999, LNCS 1606 and 1607), again in Granada (2001, LNCS 2084 and 2085), then in Maó (Menorca) (2003, LNCS 2686 and 2687) and, now, the first IWINAC in Las Palmas.

June 2005

José Mira

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