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Guest Editorial

Brain inspired cognitive systems (BICS)

This *Neurocomputing* special issue is based on selected, expanded and significantly revised versions of papers presented at the Second International Conference on Brain Inspired Cognitive Systems (BICS 2006) held at Lesvos, Greece, from 10 to 14 October 2006. The aim of BICS 2006, which followed the very successful first BICS 2004 held at Stirling, Scotland, was to bring together leading scientists and engineers who use analytic, syntactic and computational methods both to understand the prodigious processing properties of biological systems and, specifically, of the brain, and to exploit such knowledge to advance computational methods towards ever higher levels of cognitive competence. The biennial BICS Conference Series (with BICS 2008 recently held in Sao Luis, Brazil, 24–27 June, and BICS 2010 due to be held in Madrid, Spain) aims to become a major point of contact for research scientists, engineers and practitioners throughout the world in the fields of cognitive and computational systems inspired by the brain and biology.

The first paper in this special issue is by Carnell who presents an analysis of the use of Hebbian and Anti-Hebbian spike time-dependent plasticity (STDP) learning functions within the context of recurrent spiking neural networks. He shows that under specific conditions Hebbian and Anti-Hebbian learning can be considered approximately equivalent. Finally, the author demonstrates that such a network habituates to a given stimulus and is capable of detecting subtle variations in the structure of the stimuli itself.

Hodge, O'Keefe and Austin present a binary neural shape matcher using Johnson counters and chain codes. They show that images may be matched as whole images or using shape matching. Finally, they demonstrate shape matching using a binary associative-memory neural network to index and match chain codes where the chain code elements are represented by Johnson codes.

Nasuto, Bishop and de Meyer propose an information-processing paradigm in the brain, instantiated in an artificial neural network using biologically motivated temporal encoding. The network is shown to locate within the external world stimulus, the target memory, defined by a specific pattern of micro-features. Finally, the network is demonstrated to be robust and efficient which illustrates possible emergence of cognitive processing from low level interactions such as memory retrieval based on partial matching.

Serrano, del Castillo and Iglesias present a connectionist model of cognitive reading for dealing with written language semantics. Specifically, the authors propose a computational model of natural language reading, called cognitive reading indexing model (CRIM), which is shown to be inspired by certain aspects of human cognition in addition to being psychologically plausible. Their model relies on a semantic neural network that produces nets of activated concepts as text representations. Based on these representations, measures of semantic similarity are defined and human comparison results are used to show that the system is suitable to model human reading. Finally, the authors use additional results to point out that the system can be used in real applications concerning natural language processing tasks.

Bartolozzi and Indiveri show that homeostasis can be useful for solving issues such as mismatch and temperature drifts in hardware spike-based neural networks. They present a new synaptic circuit that supports both spike-based learning and homeostatic mechanisms, and show how it can be used in conjunction with a software control algorithm to model global synaptic scaling homeostatic mechanism.

Adams, Calcraft and Davey employ a genetic algorithm to investigate efficient connectivity in associative memories. The authors first investigate sparse networks of threshold units, trained with the perceptron learning rule to act as associative memories. Their units have position and are placed in a ring so that the wiring cost is a meaningful measure. A genetic algorithm is then used to evolve networks that have both efficient wiring and good functionality. The authors demonstrate that the connection strategy used by the networks appears to maintain some connectivity at all distances, but with the probability of a connection decreasing rapidly with distance.

Marques and Holland argue that the topic of imagination raises representational, physiological and phenomenological issues that cannot be tackled easily without using the body as a reference point. Within this framework, the authors define functional imagination as the mechanism that allows an embodied agent to simulate its own actions and their sensory consequences internally, and to extract behavioural benefits from doing so. The authors present five necessary and sufficient requirements for the implementation of functional imagination, as well as a minimal architecture that meets all these criteria. They also present a taxonomy for categorizing possible architectures according to their main attributes. Finally, the authors describe experiments with some simple architectures designed using these principles and implemented on simulated and real robots, including a highly complex anthropomimetic humanoid.

Chella and Macaluso describe a model of robot perception based on a comparison loop process between the effective and the expected robot input sensory data generated by a 3D robot/environment simulator. The perception loop process is

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implemented in CiceRobot, an effective robot architecture implemented on an autonomous robot offering guided tours at the Archaeological Museum of Agrigento, Italy.

The final manuscript of this special issue is by Coward and Gedeon who discuss implications of resource limitations for a conscious machine. The authors argue, citing prior work, that the way in which information handling resources are organized in an extremely complex learning system is constrained within some specific bounds if the available resources are limited, and that there is evidence that the human brain has been constrained in this way. The authors then present an architectural concept for a conscious machine that is within the architectural bounds imposed by resource limitations. Their architectural concept includes a resource driven architecture, a description of how conscious phenomena would be supported by information processes within that architecture, and a description of actual implementations of the key information processes. The authors also review other approaches to designing a conscious machine and conclude that although they could be capable of supporting human consciousness-like phenomena, they do not take into account the architectural bounds imposed by resource limitations.

Finally, the Guest Editors would like to thank the BICS 2006 authors for their contributions and all the anonymous reviewers who greatly helped improve the quality of the papers in this special issue. Special thanks go to the Editor in Chief, Tom Heskes, for very kindly inviting us to edit this special issue, and to Vera Kamphuis of *Neurocomputing* Editorial Office for her support in putting the special issue together.

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