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Guest editorial

Presenting the Special Issue on Biological Neural Networks

Scientific efforts towards understanding architectures and functional mechanisms of neural networks in the brain are confronted with an almost insurpassable level of complexity which cannot be solved by conventional neurophysiological and psychological experiments only. The development of basic concepts and general principles of operation is therefore of crucial importance in guiding the way of thinking and defining working hypotheses for further investigations. For that reason, neural networks modeling forms an essential tool in studying the consequences of these basic ideas in a rigorous way.

To be more concrete, in the modeling approach, we study how to interconnect neurons to synthesize a brain model, or a network with the same functions and abilities as the brain. When synthesizing a model, we try to follow physiological evidence as faithfully as possible. For parts that are not yet clear, we construct a hypothesis and synthesize a model that follows the hypothesis. We then analyze or simulate the behavior of the model, and compare it with that of the brain. If we find any discrepancy in behavior of the model and the brain, we change the initial hypothesis and modify the model. We then test the behavior of the model again. We repeat this procedure until the model behaves in the same way as the brain. Although we must still verify the validity of the model by physiological experimentation, it is probable that the brain uses the same mechanism as the model, because both respond in the same way. The relationship between modeling neural networks and neurophysiology resembles that between theoretical physics and experimental physics.

The modeling approach is therefore of increasing importance in neurophysiological and psychological experimentation, where testable hypotheses are in great need. With mathematical models it can convincingly be shown how complex behavior can emerge even from very simple rules of operation. Basic ideas concerning information processing in biological neural networks may also lead to new design principles for advanced artificial information processors, with many spin-offs for applied research.

In order to stimulate the modeling research, we planned this Special Issue and called for papers of all aspects regarding neural network models of the brain, and biologically relevant artificial neural networks. In the Special Issue the role of

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modeling biological neural networks is emphasized in both neurobiological and applied neural network research.

This Special Issue on Biological Neural Networks contains a set of articles which covers a very broad range of the topics of current interest. Mechanisms at all levels of biological organization are involved, ranging from molecular mechanisms to higher brain functions including visual systems and consciousness. Half of the articles in the Special Issue focus on vision, reflecting the continued importance of this topic for both the neurobiology of sensory perception and the technology of image processing. Neural network models of the visual system described in the Special Issue concern processes which include: scene segmentation, direction selectivity, preattentive vision, recognition, and the generalization of positional invariance. These models are based on neurobiologically plausible mechanisms of operation which include: temporal correlation of neural discharge, lateral inhibition, reciprocal interaction, Gaussian receptive fields, and Hebbian learning. The other articles in the Special Issue describe models which represent points on the continuum from single synapses to human consciousness. One article breaks new ground with a model of the molecular and cellular mechanisms underlying synaptic plasticity in the sensory/motor neuron synapse in the Aplysia gill-withdrawal reflex. Another explains how a hierarchically organized neural network in the brainstem can control the rhythm of respiration. A model of the superior colliculus sheds new light on the neural mechanisms that mediate the motor control of rapid eye movements. While one article describes a new neural network model of sequential memory, another explains how conscious awareness itself may be the result of competitive interactions in a distributed neural network model of memory. Taken together, the articles in this Special Issue of *Neurocomputing* underscore the broad range, richness, current excitement, and potential for progress in the area of Biological Neural Networks.

We, the Guest Editors, wish to thank the authors of these contributions and also thank the Editor-in-Chief for giving us this oportunity to contribute to the further development of this research area. We also would like to express our gratitude to all anonymous reviewers whose comment greatly improved the quality of the papers in this issue.

Kunihiko Fukushima
Sergey K. Aityan
Thomas J. Anastasio
Jaap van Pelt
Guest-editors