# Preface

This volume contains invited and contributed papers presented at the eighth edition of the International Summer School on Neural Networks, dedicated to Prof. Eduardo R. Caianiello. The school was established in 1996 by Prof. Antonio Zichichi, director of the Ettore Maiorana Centre for Scientific Culture in Erice (Sicily), and Prof. Maria Marinaro, director of the International Institute for Advanced Scientific Studies in Vietri sul Mare, in Italy. The school is held each year, alternating between Erice and Vietri, proposing surveys on several research fields related to cybernetics studies and human-machine interaction. The eighth edition of the school was on cortical dynamics and was held in Erice.

The contributions collected in this book are aimed at providing primarily high-level tutorial coverage of the fields related to cortical dynamics, reporting recent experimental and theoretical results investigating the processing, the transmission, and the imprinting of information in the brain, and important functions of the cortical area such as cortical rhythms, cortical neural plasticity, and their structural basis and functional significance.

Height surveys, reporting the most recent original results, are offered by specialists in the field. Consequently, the volume may be used as a reference book on models of cortical dynamics from neuroscience and physics. To this aim the volume is divided into two sections: fundamentals of cortical dynamics, and mathematical models of cortical dynamics.

Fundamentals of cortical dynamics deals with problems related to the functioning of the brain in complex biological systems, their organization and the existence of hierarchies and multiple-scale networks at several levels of miniaturization and information processing. Fundamental and innovative ideas in neuroscience are covered. This section contains three tutorial papers. The first tutorial, authored by Bruce P. Graham, discusses underlying dynamic signal processing within hippocampal pyramidal cells, their properties and their functioning as associative memories. The second, by Luigi Agnati and colleagues, describes and accounts for various basic features and functions of the central nervous system (CNS), suggesting that the understanding of its functioning is better explained by hypothesizing nested hierarchical structures of computational devices that process incoming input signals at different computational levels of miniaturization and then integrate both spatial and temporal relationships among informational elements and computations, exhibiting emergent behaviors. Finally, the tutorial by Alessandro Treves reports on the physiological changes that may have occurred during the evolutionary process in the neuronal circuitry and may have contributed to the development of a fundamental neuronal mechanism such as the firing rate adaptation.

Mathematical models of cortical dynamics deals with the mathematical modeling and computer simulation of the brain's functions. Inspired by the recent discoveries on the chaotic behavior of neuronal cells and supported by the need

to find solutions for approximating the probability distributions of the cortical cell's dynamics, this research aims to describe brain dynamics using theoretical neural networks models. To this aim it appears that mean field theory (MFT) and chaotic theory offer realistic interpretations. The first paper in this section, authored by John Hertz and colleagues, shows how mean field theory is able to model appropriately the dynamics of dense, randomly connected cortical circuits, their firing statistics and the correlations among them. The second paper, by Fortunato Tito Arecchi, describes the process of "feature binding", i.e., the capacity of the brain to combine external data with internal memories into coherent patterns of meaning, and its modeling through homoclinic chaos (HC). The following three papers demonstrate how several characteristics observed in the dynamic activity of the brain can be mathematically modeled in terms of the information theory of chaos. The first paper of this series, authored by Ichiro Tsuda and Hiroshi Fujii, provides a mathematical model that accounts for the instability and the nonstationary features of the cortical activity through the theory of chaotic itinerancy (CI). The second, authored by Ichiro Tsuda and Shigeru Kuroda, proposes a computational model for the formation of episodic memory based on cantor coding theory. Finally, the last paper of the series, authored by Hiroshi Fujii and Ichiro Tsuda, shows how the behavior of some interneuron systems in the neocortex generates a variety of synchronous inhibitory rhythms that could be mathematically described by an expression of chaotic itinerancy between pseudoattractors.

The editors would like to thank the University of Salerno, the Regione Campania, the Ettore Majorana Center for Scientific Studies, the Italian Neural Network Society, the Italian Ministry for Education and Scientific Reserarch (MIUR), and the International Institute for Advanced Scientific Studies "E.R. Caianiello", for their support in sponsoring, financing, and organizing the school. In addition, the editors are grateful to the contributors of this volume whose work stimulated an extremely interesting interaction with the attendees, who in turn shall not be forgotten for being so highly motivated and bright. This book is dedicated to the memory of Prof. Eduardo Renato Caianiello, who disappeared 10 years ago from the scientific scene. His work and his dedication to research in cybernetics is still alive in all of us and continue to stimulate our research work.

Peter Erdi, Anna Esposito, Maria Marinaro, Silvia Scarpetta

# Organization

The eighth edition of the International School on Neural Nets "E.R. Caianiello", titled *Computational Neuroscience: Cortical Dynamics*, was held from October 31 to November 7, 2003, at the Center for Scientific Culture EMFCSC in Erice in Italy.

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