

# Preface

The neurocomputing is endowed with an opportunity to realize the innate enigma of artificial intelligence in physical world. The researchers of modern computing science have sought to see the neurocomputing as cutting edge technology in computational intelligence and machine learning. The goal of this book is to bring in the elegant theory of neurocomputing that underlies high-dimensional computing and inspire the readers by presentation that the theory is vibrant. It provides a comprehensive foundation of *High-Dimensional Neurocomputing* and represents technology that is rooted in many disciplines. Most significantly, the book emphasizes an aspect of this field that cannot be neglected, that there is a wide experimental side to the practice of *High-Dimensional Neurocomputing*. I tried to strike a balance between theory and practice. It is a speedily expanding field. The book presents a solitary and coherent picture of how to empathize neural function from single neuron to typical networks. I have preferred to present only that material appropriate in constructing a unified framework. Clearly documented and extensively accepted standards presented in the book play a pivotal role for modern computing system. A distinguishing feature of the book is its contents and style of presentation, which I believe, provide an excellent platform for those who want to take up research career in intelligent optimization techniques and engineers who want to implement neurocomputing.

An artificial neuron is the mathematical model of the biological neuron and approximates its functional capabilities. Ever since we invented the idea of artificial neural network, which can learn and generalize, the study of what can be computed and how it can be done well was launched. In the beginning of the twenty-first century, several scientific communities have converged on a common set of issues surrounding various high-dimensional problems. Rumelhart et al. [1] demonstrated that the computing power of an artificial neural network can be enhanced by increasing the number of layers, and this book exhibits that extending the dimensionality of neuron in neural networks originates the similar or better effect on neurocomputing. Boosting the power by extending the dimensionality of neuron in neural networks has been widely accepted for vital high-dimensional applications. A solution to the high-dimensional problem through high-dimensional neural

networks, consisting of neuron accepting high-dimensional vector signals (for example, complex numbers and quaternions,  $N$ -dimensional vector) is a new directionality for enhancing the ability of neural networks, therefore, is worth researching.

I assume that the readers of the book have a strong background of artificial neural networks in single dimension. In this book, I want to move you above these rudiments by providing you with the tools and techniques, necessary to design and implement high-dimensional neural networks. If we try to identify representation of high-dimensional data as a single cluster (vector or number) than it will be enduring as preferred impinging signals to neuron and surely the refinement in the concepts of neurocomputing. Number or Vector is one of the most elementary notions not only in mathematics, but also in universal science as well. Mathematicians were always fascinated with the possibility of extending the above notion to numbers of high-dimensionality, which follow straightforward algebraic properties. The solution was found when the multi-component numbers or real-valued vectors, as being structures (clusters) subjected to arithmetic properties, were investigated and later successfully utilized in *High-Dimensional Neurocomputing*. This book, inspired by the high-dimensional applications, has led to investigation of many important intelligent computing methodologies. It is the purpose of the book to organize what is known about them in coherent fashion so that students and practitioners can devise and analyze new tools and paradigms for themselves.

In order to provide a high computational power, many attempts have been made to design neural networks, taking account of task domains. Artificial neural network in complex domain is the first and foremost a synthesis of current ideas in theoretical neurocomputing. Complex-valued neural networks whose parameters (input-output, weights and threshold values) are all complex numbers, are suitable for the two-dimensional problems; Not surprisingly, it has also outperformed even for single-dimensional problems. There is another directionality in making the computing power of an artificial neuron high is to devise new form of higher order computing structures. I have adopted and refined the ideas about higher order neurons, both theoretical and practical insight, into the functioning of neural system. I strongly feel that the emphasis on the design as well as on analysis of higher order neuron models in complex domain is the appropriate way to organize the study of neurocomputing. This book does focus on the design of higher order neuron models as well as principles for modeling diverse neural systems. Attempting to construct a general framework for understanding neurocomputing systems provides a novel way to address the theme of the book.

We are seeing a faster and faster move from rule-based system to methods based neurocomputing techniques that learn automatically from very large corpus of examples. They were widely accepted as a rudimentary attempt to generate a coherent understanding of neurocomputing from the perspective of what has become known as machine learning. The machine learning has seen speedy developments since the evolution of high-dimensional neural computing (HDNC). This book discusses many methods related to high-dimensional machine learning that have their bases in different fields: statistics, pattern recognition, biometrics

control, computer vision, robotics, etc. HDNC seeks to unify the many diverse strands of machine learning research and to foster high quality innovative applications.

This book presents a readable and concise material to HDNC that reflects the diverse research strands while providing a unified treatment of the field. The book covers all of the main problem formulations and introduces the most important algorithms and techniques encompassing methods from computer science, neural computation, information theory, and statistics. The prerequisites for the successful study of HDNC are primarily a background in traditional neural networks, linear algebra, hypercomplex numbers, multivariate statistics, and differentiability in high dimensions. This book expands and updates coverage of several areas, particularly computer vision, machine learning, and biometric applications that have advanced rapidly over the last decade. The intended audience is quite broad, but mainly consists of the growing number of engineers working in industry, computer scientist, neuroscientist, physicist, and several neurocomputing community interested in learning more about how their quantitative tools relate to the brain. This book is also intended for senior undergraduate, graduate, and seasoned researchers. The researchers will be benefited by discussing the extra research papers; in such case, I hope that the references at the end will provide readers with additional information. My dream in writing this book will be successful if the readers are benefited from this book.

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Bipin Kumar Tripathi

## Reference

1. Rumelhart, D.E. et al.: Parallel Distributed Processing, vol. 1. MIT Press, Cambridge (1986)

High Dimensional Neurocomputing

Growth, Appraisal and Applications

Tripathi, B.K.

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