# Complex-Valued Neural Networks with Multi-Valued Neurons: Theory and Applications

**Prof. Igor Aizenberg**
Department of Computer Science
Manhattan College, New York, USA

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**Aula Caminetto, Scuola di Ingegneria, Via Santa Marta 3, Firenze**

**Abstract**. The lectures are devoted to fundamentals and applications of complex-valued neural networks with multi-valued neurons. Due to the computational and theoretical advantages that processing in the complex domain offers over the real-valued domain, the area of complex-valued neural networks is one of fastest growing research areas in the neural network community. In addition, recent progress in pattern recognition, robotics, mathematical biosciences, brain-computer interface design has brought to light problems where nonlinearity, multidimensional data natures, uncertainty, and complexity play major roles – complex-valued neural networks are a natural model to account for these applications.

The most important notion underlying the theory of complex-valued neural networks is that of the phase information. The multi-valued neuron (MVN) is a complex-valued neuron with the inputs and output located on the unit circle. MVN has a circular activation function, which depends only on phase and projects a weighted sum onto the unit circle. These specific properties determine many unique advantages of MVN. The most important of them are the ability of MVN to learn non-linearly separable input/output mappings without any network and simplicity of derivative-free learning, which is based on the error-correction rule. MVN-based complex-valued neural networks also have a number of unique advantages. MVN-based Hopfield neural networks have shown unique capabilities as associative memories. The multilayer feedforward neural network with multi-valued neurons (MLMVN) significantly outperforms a classical multilayer perceptron (MLP) and many kernel-based techniques including SVM in terms of generalization capability and the number of parameters employed.

The following topics will be covered:

1. Complex-valued neurons vs. real-valued neurons: higher functionality, possibility to learn non-linearly separable input/output mappings using a single neuron, proper treatment of phase, multi-valued neuron and its error-correction learning algorithm.

2. Multilayer neural network with multi-valued neurons (MLMVN): derivative-free backpropagation learning based on the generalized error-correction learning rule, batch learning.

3. Applications of MLMVN: solving various classification, pattern recognition, and time series prediction problems.

4. Intelligent image and signal filtering using MLMVN.

5. Image recognition using MLMVN-based analysis of frequency domain features.

**Biography**. Igor Aizenberg received the M.Sc. degree in Mathematics from Uzhhorod National University (Ukraine) in 1982, and the Ph.D. degree in Computer Science from the Dorodnicyn Computing Center of the Academy of Sciences of the USSR (Moscow, Russia) in 1986, respectively. In 1982-1990, he was a Research Scientist with the Institute for Information Transmission Problems of the Academy of Sciences of the USSR (Moscow, Russia). In 1990-1993, he was an Assistant Professor and then in 1993-1996 and 1998-1999, he was an Associate Professor with the Department of Cybernetics at Uzhhorod National University (Uzhhorod, Ukraine). In 1996-1998, he was a Research Scientist with the Department of Electrical Engineering at the Catholic University of Leuven (Leuven, KU Leuven, Belgium). In 1999-2002, he was a Chief Research Scientist and VP Research at the company "Neural Networks Technologies" (Israel). In 2002-2006, he was a Visiting Research Professor at the University of Dortmund (Dortmund, Germany) and Tampere University of Technology (Tampere, Finland). In 2006-2016, he was Professor with the Department of Computer Science and Director of the Computational Intelligence Lab, Texas A&M University-Texarkana (Texarkana, TX, USA). Since August 2016 he is Professor and Chair of the Department of Computer Science at Manhattan College (New York City, USA). Dr. Igor Aizenberg has also recently served as an invited Visiting Professor at the Polytechnic of Porto (Porto, Portugal), National Sun Yat Sen University (Kaohsiung City, Taiwan), Masaryk University (Brno, Czech Republic), and National Polytechnic Institute of Mexico (Mexico City, Mexico).

Research interests include complex-valued neural networks, pattern recognition, intelligent image processing, and spectral techniques. Dr. Aizenberg is one of the co-founders of complex-valued neural networks.

***Per informazioni:***
***Prof. Ing. Antonio Luchetta***
***Dip.to Ingegneria dell'Informazione (DINFO) - Firenze***
***Tel. 055 2758616***
***Email: luchetta@unifi.it***