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Prof. George J. Tsekouras

Image Analysis Inspired by Physical Electro-Magnetic Fields

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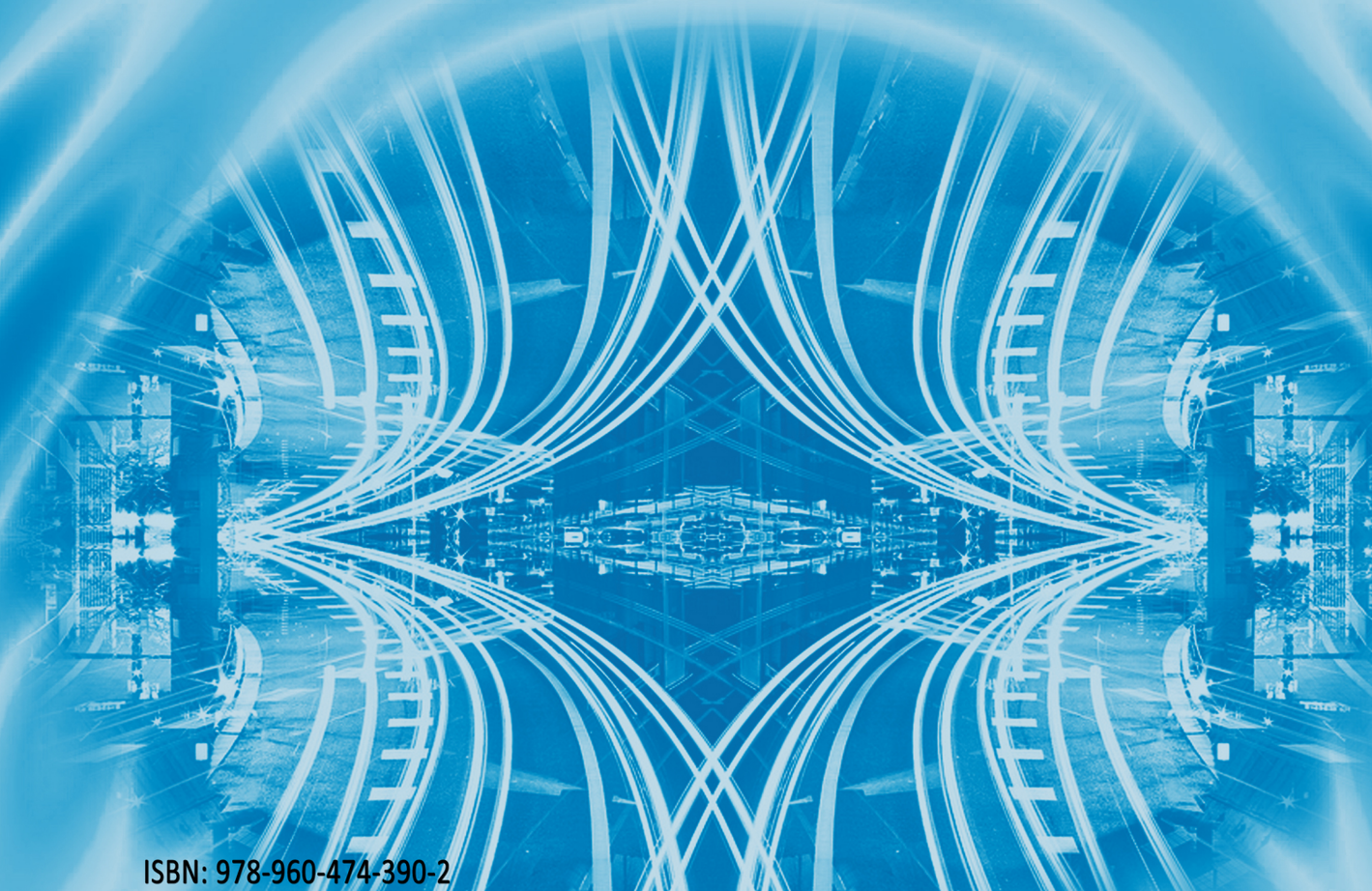
by Dr. Xiaodong Zhuang and Prof. Nikos Mastorakis



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Preface

Nature has enormous power and intelligence behind its common daily appearance, and it is generous. The development of human society relies on natural resources in every area (both material and spiritual). We learn in it and from it, virtually as part of it. Nature-inspired systems and methods have a long history in human science and technology. For example, in the area of computer science, the recent well-known ones include the artificial neural network, genetic algorithm and swarm intelligence, which solve hard problems by imitating mechanisms in nature. Nature-inspired methods are also being quickly developed and applied in other areas. In this book, we just try to pick up a drop from the sea of nature's intelligence, and apply it in a specific area. We hope that it may inspire the readers' interest of nature's intelligence when exploring in their own areas of science and technology.

Traditional image processing methods usually take images as data sets or mathematical functions. In our idea of nature-inspired methods, images are more like the imitation of certain natural entities (such as electric charges, currents, etc.) simulated in computer. The evolutions of such virtual entities can be simulated according to corresponding natural laws and the simulation result can be studied for possible utilization in practical image processing tasks. Nowadays, nature-inspired methods in image processing have attracted more and more attention and research efforts. Physics and biology are the two main sources from which most of such methods have derived. Related work has achieved promising results in practical tasks, which indicate that it is a direction potentially leading to breakthroughs of new image analysis techniques. Methods inspired by physical electro-magnetic field make up a branch of this field, which have been successfully applied in the practical applications including: recognition of human ear, face and gait; extraction of corner, edge, and shape skeleton in images. The existing methods inspired by electro-magnetic theory generally belong to two categories: analysis of the virtual field generated by the image (such as the "force field transform") and deforming a shape or curve under the virtual force field generated by the image (such as the "active counter model").

The beginning of the research introduced in this book was in 2006, after we read a paper about "force field energy functionals for image feature extraction" (David J. Hurley, Mark S. Nixon, John N. Carter, 2002). This paper inspired our strong interest of natural analogies in image processing. Since then, we have been exploring in the area of nature-inspired image analysis for years and have published a series of papers about our original methods and results. These methods are mainly inspired by the theory of electro-magnetic field, which reveal the structure properties of the image by electro-magnetics inspired transforms. In these transforms, the formulas in electro-magnetic theory are adjusted to more generalized forms in order to suit practical image analysis tasks, and some novel viewpoints which take the image as a virtual field are presented. Several types of methods have been proposed from different aspects of field theory (vector field, scalar potential field, and field source distribution), which indicates that the physics inspired virtual field is a novel way of designing new effective image transforms.

Nature-inspired methodology itself means continuous exploration in the rich resource of the intelligence shown by nature. Therefore, this book does not mean the final conclusion of the authors' on-going work. Further promising results in both theory and practice are expected and we hope our research attempts shown in the book may inspire new ideas of others, which will surely be much more valuable than the book itself.

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The Authors

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